AD-A169 675 ENVIRONMENTALLY ACCEPTABLE COATINGS: LATEX COATINGS FOR WOOD (PLYWOODS)(U) NAVAL CIVIL ENGINEERING LAB PORT HUENEME CA E S MATSUI ET AL. MAY 86 NCEL-TN-1751 1/2

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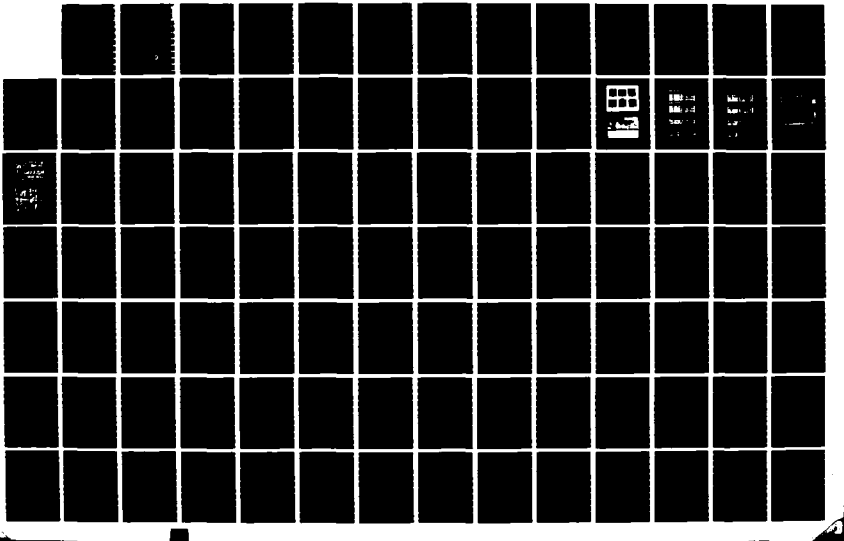

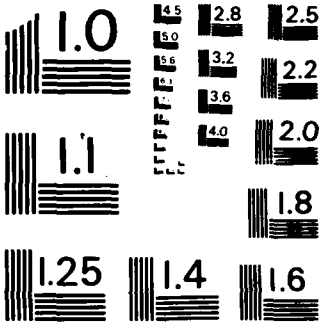

MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS - 1963 -

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May 1986

NCEL
Technical Note

By E.S. Matsui and R.W. Drisko

Sponsored by Naval Facilities
Engineering Command

ENVIRONMENTALLY ACCEPTABLE COATINGS: LATEX COATINGS FOR WOOD (PLYWOODS)

ABSTRACT Coatings presently used on Navy shore facilities are mostly of the alkyd type, which use organic solvents in their formulation. These solvents present environmental problems because they contribute to the production of photochemical smog. The Naval Civil Engineering Laboratory conducted an investigation into the use of latex coatings on plywood to determine to what extent (1) they could be used as alternatives to alkyd paints without loss of performance and (2) performance could be predicted. It was found that latex coating systems can be satisfactorily substituted for traditional solvent-type alkyd coating systems on wood substrates. By a statistical analysis of penetration data, it should be possible to predict field performance of coatings.

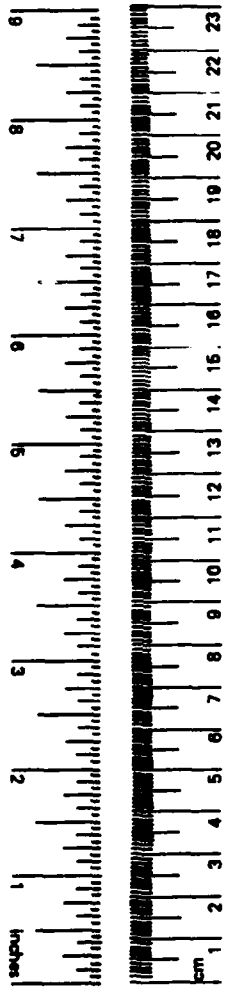
NAVAL CIVIL ENGINEERING LABORATORY PORT HUENEME CALIFORNIA 93043

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

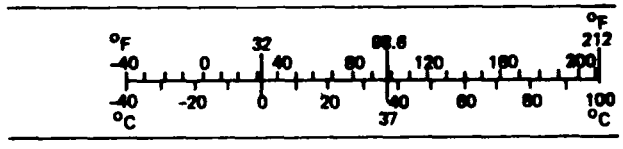
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2,000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1,000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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20 ABSTRACT (Continue on reverse side if necessary and identify by block number)

Coatings presently used on Navy shore facilities are mostly of the alkyd type, which use organic solvents in their formulation. These solvents present environmental problems because they contribute to the production of photochemical smog. The Naval Civil Engineering Laboratory conducted an investigation into the use of latex coatings on plywood to determine to what extent (1) they could be used as alternatives to alkyd paints without loss of performance and (2) performance could be predicted. It was found

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20. Continued.

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CONTENTS

INTRODUCTION

The facilities of the Naval Shore Establishment have an estimated replacement value of $88 billion (excluding land) (Ref 1), with an annual expenditure for construction and maintenance of $5 billion. Because most of the structures in the Naval Shore Establishment are over 30 years old and are not designed for modern, efficient maintenance, maintenance costs are unusually high--about $800 million annually. A Naval Civil Engineering Laboratory (NCEL) study in 1981 (Ref 2) indicated that for Norfolk Naval Station painting costs represent about 10% of the total maintenance expense. Extrapolating these data Navywide means about $90 million is spend annually on painting. Wood in housing and other buildings at shore activities is especially susceptible to weathering because its grain structure tends to swell and crack with prolonged exposure to moisture and natural weathering, thus requiring frequent painting.

Many regional areas are currently restricting the use of oil-based coatings for wood and other substrates because the organic solvents in these coatings contribute significantly to the production of photochemical smog (Ref 3 and 4). Because of this, the Naval Facilities Engineering Command (NAVFAC) has assigned responsibility and delegated authority to NCEL to find or develop alternative environmentally acceptable coating systems and application requirements that meet all Government regulations concerning volatile organic solvents. These new coating systems must provide at least the same level of protection to Navy shore facilities as presently provided by nonconforming systems. The physical, chemical, and performance criteria established from this effort will then be used in NAVFAC guide specifications and manuals as guidance to field activities.

This program encompasses environmentally acceptable (1) latex coating systems for plywood; (2) waterborne or high-solid epoxy, alkyd, and urethane coating systems for steel; and (3) special-purpose coating systems for facilities such as antenna structures, waste treatment tanks, and mooring buoys.

This report describes the investigation of latex coatings for plywood to determine to what extent a successful substitution could be made and to what extent performance can be predicted from original paint properties. Plywood was used because its surfaces have the uniformity necessary for reproducible results. The surfaces of other timbers vary greatly in amounts of flat and edge grain. This report also describes the testing program, results of the laboratory and field tests, and the condition of test panels exposed to a severe marine atmospheric environment for 4 years. This report also identifies the best performing latex coating system and recommends it as a substitute for organic solvent-type alkyd coatings that are currently restricted by environmental regulations.

TEST PROGRAM

Oil-based coatings are generally believed to be more appropriate than latex coatings for wooden surfaces because of wetting, penetrating, and sealing properties. Latex coatings, particularly topcoats, have been receiving greater use on wood lately because of their environmental acceptability, as well as other useful properties. The present study was initiated to compare the performance of alkyd (oil-based) and latex coatings on wood, as well as the performance of latex-over-alkyd coatings and vice versa. Data on mixed systems will permit recommendations for recoating existing coated structures.

The coating systems tested included both experimental and presently marketed (both specification and proprietary) materials to provide information on both present short-term and future long-term recommendations. Thus, both 6.2 (exploratory development) and engineering investigation funds were used. The actual coating systems investigated are listed in Table 1. Available formulations, laboratory analyses, and sources of these coatings are presented in Appendixes A, B, and C, respectively.

Twenty-two coating systems were applied in triplicate (Figure 1) to the fronts and backs of rough-sawn and smooth plywood (grade A-C Douglas fir) panels (a total of 132). Panel dimensions were 12 by 12 by 5/8 inch. Surfaces were brushed lightly by hand using a medium hard bristle brush before coating. One coat of primer and two coats of topcoat were brushed onto each panel. After curing, the edges were dipped in special sealer (Imperial aluminum edge seal) to prevent accelerated deterioration at exposed edges.

Two sets of the coated panels (total of 88) were shipped to the NCEL test site at Kwajalein, Marshall Islands, for exposure in a severe marine atmospheric environment (Figure 2). Kwajalein is near the center of the tropical zone at 8°44' N. latitude. The exposure racks are located about 100 feet from the surfline at high tide and hold the test panels at a 45-degree angle to the horizontal, facing the prevailing east-northeast wind that carries large amounts of salt-laden moisture onto the panels. Rainfall is plentiful, averaging over 10 in./mo during 8 months of the year; total annual rainfall is about 105 inches. The annual average temperature range is 81 to 83°F, and wind velocity is between 8 and 21 mph.

The third (unexposed) set (total of 44) was used for laboratory testing of initial adhesion and depth of coating penetration. After 2 years of exposure and at the conclusion of the test (4 years), one set each was brought back to the laboratory to determine changes in adhesion.

Field specimens at Kwajalein were rated semiannually for general protection, discoloration, chalking, checking, cracking, flaking, erosion, blistering, and mildew. American Society for Testing and Materials (ASTM) rating standards were used for recording the degree of protection given by a coating; a rating of 10 indicated complete protection, and a rating of 0 indicated no protection. For this report, a protection rating of 7 indicated coating failure.

In determining the bonding strengths of the coating systems to the wooden surfaces, a minimum of five sandblasted steel dumbbell-shaped probes, 1 cm^2 in end area, were abrasive blasted to a white metal finish and bonded to each coated specimen with an epoxy adhesive (Hysol EA9309).

After 3 days of curing, the probes were pulled at a rate of 0.5 cm/min by a table model Instron testing machine until failure occurred. Both the type of failure and the magnitude (to the nearest 0.1 kg/cm) were recorded. Bonding strengths were measured on unexposed specimens and specimens exposed for 2 and 4 years to determine the effects of weathering on bonding strength. The correlation between bonding strength and coating performance was also determined.

Penetration studies were conducted using calibrated light microscopes on thin sections of coated wood sliced with a microtome. Since the penetrations were unevenly distributed and thus difficult to measure, a planimeter was used to measure the cross-sectional area of penetration from a photograph taken through a microscope. Penetration was calculated from the planimeter measurements and the magnification. Correlations between penetration and bonding strength and between penetration and performance were determined.

RESULTS OF TESTING AND DISCUSSION

Weathering

Appendix D contains semiannual ratings of coated panels exposed at Kwajalein for 4 years. Each item was rated and tabulated separately in Tables D-1 through D-36 of Appendix D according to category. Figures 3 and 4 are graphical summarizations of the performance of all 22 coating systems exposed for 1, 2, 3, and 4 years as recorded in Appendix D, respectively. The shaded areas of each block represent the degree of failure in discoloration, chalking, checking, cracking, flaking, erosion, blistering, mildew, and general protection, respectively. No shading in the block means excellent performance (rating of 10), a half-shaded block means fair performance (rating of 8 to 9), and a completely shaded block means poor performance (rating of 7 or below). Bonding strengths after 48 months are listed along with a chart to assist in the overall review of the relationship between coating performance and bonding strength. After 4 years in the severe marine atmospheric environment at Kwajalein, some of the coatings had shown considerable wear and deterioration (Figure 5). Differences in their performance become more pronounced as the shaded areas in Figures 3 and 4 of some of the coating systems increase.

To compare and evaluate the relative performance of each of the 22 coating systems, the fourth- and third-year performance ratings were ranked and listed in Tables E-1 through E-18 in Appendix E separately according to category. The scores were obtained from the 48-month rating tables of the respective category listed in Appendix D. For example, the scores for general protection in Table E-1 were obtained from the average (smooth and rough-sawn surfaces) of 48 months of general protection ratings in Table D-4 and arranged according to rank. The scores for general protection in Table E-2 were prepared similarly from the average of 36 months of general protection ratings in Table D-3 and arranged according to rank. First- and second-year performance ratings were not presented here to simplify this report and because the coatings were not deteriorated sufficiently to show significant differences among them.

General Protection. Table E-1 reveals that the first 15 top performing coating systems consisted of latex primer and latex topcoat. Furthermore, all of the 14 top performing coatings were topcoated with proprietary products. The last eight (poorest performing) coating systems used Government specification primers and topcoats, except for System 22. System 22 is a proprietary product formulated with a water-reducible alkyd resin.

Among the proprietary products, Sinclair 1300, 4400, and 4800 ranked 1st, tied for 3rd, and 6th, respectively, in the area of general protection. One of the three UCAR paints tied at 3rd and the other two were tied at 10th. Two of these three UCAR paints tied at 2nd and the other at 7th 1 year earlier. SUNCO was ranked 2nd. Standard Brands paints ranked 3rd, 6th, two tied at 8th, and 12th. The coating systems topcoated with specification paints trailed at 15th to 22nd, except for proprietary System 22, which ranked 20th.

Among the specification systems, the latex-over-latex (latex/latex) performed better than the latex-over-alkyd (latex/alkyd) coating system. System 1, an alkyd-over-alkyd (alkyd/alkyd) system, performed the poorest of all.

The Sinclair paints provided the best general protection, followed by SUNCO, UCAR, and Standard Brands, respectively. All specification coating systems were rated inferior to the proprietary systems tested. Coatings performed significantly better on rough-sawn than on smooth plywood, when the general protection averages of specimens with the two surfaces shown in Tables D-1 through D-4 were statistically analyzed.

Latex paints provided better general protection probably because their resins retained greater flexibility than did the alkyd resins during weathering. The drying oil portions of alkyd formulations continue to cross-link (polymerize) during weathering to become more rigid.

Discoloration. Table E-3 revealed that Sinclair 1300 again ranked 1st on the discoloration rating, and other Sinclair paints ranked 4th and 10th. SUNCO was tied at 2nd. Standard Brands paint, F6674-5, was showing good resistance to discoloration and tied at 2nd, while three other Standard Brands paints ranked 4th and two tied at 7th. UCAR paints ranked 4th, 7th, 12th, and 14th. Here again, test panels topcoated with specification paints ranked lower, from 11th to 21st.

Latex/latex systems performed better than the alkyd/latex, latex/alkyd, and alkyd/alkyd coating systems. The specification paints had greater discoloration than the proprietary products tested. There was no significant difference in coating discoloration on the rough-sawn and the smooth plywood specimens, as shown in Table D-2.

Chalking. Chalking is the formation of loose powder at, or just beneath, the surface of the paint as a result of decomposition of the paint resin by ultraviolet light. Table E-5 reveals that the UCAR paints were most chalk resistant; one ranked 1st, two tied at 4th, and another ranked 11th. Sinclair paints ranked 2nd and two tied at 8th. They were all latex/latex coating systems. Among the specification paints, systems with TT-E-529 (alkyd) topcoat were more chalk resistant than those with latex topcoats (TT-P-19, TT-P-1510, or TT-P-96). Two of the TT-E-529 topcoated systems tied for 11th. Other specification systems ranked 16th to 22nd.

Latex/latex coating systems were more chalk resistant than the latex/alkyd, alkyd/latex, or alkyd/alkyd coating systems. The proprietary products tested were found to be much more chalk resistant than the specification coatings tested. Among the specification coatings, alkyd-topcoated coatings were more chalk resistant than latex-topcoated coatings. The coatings on the rough-sawn plywood exhibited less chalking than the coatings on the smooth plywood at a later stage as indicated in Tables D-9 through D-12.

Checking. Checking is a condition with slight breaks in the paint film that do not penetrate to the substrate. There was no checking on all three Sinclair paints, two of the UCAR paints, one of the Standard Brands paints (Figure 6), and the SUNCO paint. These proprietary products tied for first. Checking appeared on all specification paints in varying degrees, ranking 14th to 22nd. Among the specification paints, Table E-7 reveals that TT-P-19 was more resistant to checking than TT-P-1510, TT-E-529, or TT-P-96.

As a group, proprietary products were more resistant to checking than specification coatings. Latex/latex systems were more resistant to checking than the alkyd/latex, alkyd/alkyd, or latex/alkyd coating systems. As a group, Sinclair brands were the most resistant to checking followed by UCAR, SUNCO, and Standard Brands. Specification paint TT-E-529 was the least resistant to checking and ranked 22nd. Tables D-13 through D-16 show that, except for the first 12 months, coatings on the rough-sawn plywood exhibited less checking than on the smooth plywood.

Cracking. Cracking differs from checking in that the breaks in the paint film extend to the substrate. There was no cracking on two all-latex systems, one of the Sinclair paints, and the SUNCO paint. Proprietary products ranked 1st to 13th. Although most of the specification paints were also latex, they formed more cracks (Figure 7) than the proprietary products and were rated lower, 14th and below. The specification paints primed with TT-P-001984 latex primer and topcoated with TT-E-529, TT-P-19, TT-P-1510, or TT-E-96 were all ranked 17th or below. Among the specification paints, the system with the latex topcoat over the alkyd primer (MIL-P-28582) showed less cracking than the system with the latex topcoat over the latex primer. System 1, MIL-P-28582 alkyd primer and TT-E-529 alkyd topcoat, exhibited the most cracking, ranking 22nd.

As a group, latex/latex coating systems exhibited less cracking than did the alkyd/latex, latex/alkyd, or alkyd/alkyd coating systems. Sinclair paints exhibited the least cracking, followed by SUNCO, UCAR, and Standard Brands. More cracking was found on the specification topcoats than the proprietary products. Coatings on the rough-sawn plywood cracked much less than on the smooth plywood, as indicated in Tables D-17 through D-20. The difference in degree of cracking between them was statistically highly significant.

Flaking. Flaking and peeling result when a paint film loses adhesion to the substrate or to another coat of paint. Flaking is the loosening of small pieces of paint. There was no flaking on all three Sinclair paints, two UCAR paints, SUNCO, and two of the Standard Brands

paints, as indicated in Table E-11. Flaking occurred on all of the specification paints to varying degrees. System 1 (MIL-P-28582/TT-E-529), alkyd/alkyd, peeled the most and ranked 22nd (Figure 5), preceded by Amoco (water-reducible alkyd/alkyd), which ranked 21st.

Latex/latex coating systems were more resistant to flaking than the alkyd/latex, latex/alkyd, or alkyd/alkyd coating systems. Sinclair, UCAR, and SUNCO had the highest flake resistance, closely followed by Standard Brands. All specification coatings had less flake resistance than the proprietary coatings in Table E-11. Their differences were statistically significant. The coatings on the rough-sawn plywood flaked much less than the coatings on the smooth plywood as shown in Tables D-21 through D-24. The difference between them was statistically significant.

Erosion. Erosion is the natural sequence of wearing away (weathering by sun and rain) of the finish to expose the substrate or undercoat and is thus a consequence of chalking. As a group, the proprietary latex paints fared well, while all the specification paints showed considerable erosion after 4 years of exposure, as shown in Table E-13. The latex/latex coating systems were more erosion resistant than the alkyd/latex, latex/alkyd, and alkyd/alkyd systems. System 22, which consisted of water-reducible alkyds, was the least erosion resistant. The coatings on the rough-sawn plywood appeared to be eroded slightly less than the coatings on the smooth plywood as shown in Tables D-25 through D-28. However, statistical analysis failed to show any significant difference between them.

Blistering. There was no blistering on any of the coating systems through 4 years of exposure, as indicated in Tables D-29 through D-32. Thus, they were all rated 10 and ranked the same, as shown in Tables E-15 and E-16.

Mildew. During the 4 years of exposure, mildewlike greenish stains appeared on some of the test panels. However, microscopic examination at the laboratory found no mildew-related microorganisms present. Thus, the mildewlike stains were considered dirt stains and the previous mildew rating was corrected. All were rated 10 and ranked the same, as shown in Tables E-17 and E-18.

Overall Performance. To compare and evaluate the overall relative performance of each of the 22 coating systems tested, the averages of each rated item after 4 years of exposure (listed in Tables D-4, D-8, D-12, D-16, D-20, D-24, D-28, D-32, and D-36 in Appendix D) were combined and averaged for an overall score for each coating system and listed in Table 2 according to rank. For example, the score for System 18 (9.60), the top performer, was obtained by averaging the 48-month ratings for general protection (9.55), discoloration (9.50), chalking (8.00), checking (10.00), cracking (9.67), flaking (10.00), erosion (9.66), blistering (10.00), and mildew (10.00) listed in Tables D-4, D-8, D-12, D-16, D-20, D-24, D-28, D-32, and D-36, respectively, in Appendix D. To compare the fourth-year performance with the performance of the preceding years, the overall relative performance of the first, second, and third years was similarly prepared and is presented in Appendix F.

Table 2 shows that Sinclair 1300 and 4400 ranked 1st and 2nd, respectively, after 4 years of exposure. SUNCO tied at 2nd. UCAR 19-92-C, previously tied at 1st at the end of 3 years of exposure, ranked 8th this time because of increased cracking and slight flaking during the fourth year of exposure. Other UCAR coatings, 19-93-A and 19-92-A, ranked 5th and 7th. UCAR 19-92-B ranked 13th because considerably more chalking, checking, cracking, peeling, and erosion developed compared to the other three UCAR products, as illustrated in Tables E-5, E-7, E-9, E-11, and E-13. Five Standard Brands coatings ranked 6th and 9th through 12th.

Seven specification topcoated systems, Systems 1 to 3 and Systems 5 to 8, ranked 15th and below, as shown in Table 2. The specification paints continued to exhibit relatively poor performance in all categories except blistering and mildew since the beginning of the exposure tests, as shown in Tables F-1, F-2, F-3, and F-4 of Appendix F. There was no blistering or mildew on any of the 22 coating systems tested as illustrated in Tables D-29 through D-36 of Appendix D. All the panels topcoated with specification coatings became noticeably chalky and discolored and had low checking and cracking ratings compared to the proprietary products tested, as indicated in Appendix D.

In summary, field exposure results indicate that the proprietary products performed quite well on plywood, while the specification coatings performed relatively poorly. The major difference in composition between the specification paints and proprietary coatings analyzed (Appendix B) is that the specification paints contained a significantly higher concentration of pigment to nonvolatile vehicle than the proprietary products, as shown in Table 3. The relatively high pigment concentration could have included cheaper extender pigment to lower the cost. Extender pigments permit very high transmission of ultraviolet light and thus do not protect the binder well (Ref 5). This can result in greater chalking, erosion, cracking, and brittleness of the paint. Conversely, the specification paints contained considerably less nonvolatile resin compared to the proprietary products. When pigment is excessive and vehicle solid is too low, the coating would have lower tensile strength, elongation and adhesion and would become porous, brittle, and permeable to moisture (Ref 5).

Since paint formulations for the top performing paints (Sinclair AP8-11 primer and Sinclair 1300 and 4400 finish paints) were not provided by the manufacturer, further compositional breakdown and performance tests were conducted on these paints at the Mare Island Naval Shipyard Paint Laboratory according to tests required in specifications TT-P-19 and TT-P-1984, as appropriate, to establish product criteria. The results are listed in Tables G-1, G-2, and G-3, respectively, in Appendix G.

Statistical analysis indicates that coating systems on rough-sawn surfaces performed significantly better than the same coating systems on smooth surfaces in all categories. These include chalking, checking, cracking, flaking, and erosion, as shown in Tables D-1 through D-36 in Appendix D.

Latex/latex coating systems performed significantly better than the alkyd/latex, latex/alkyd, or alkyd/alkyd coating systems.

Adhesion

The initial bonding strengths and those after 2 and 4 years of exposure at Kwajalein are summarized in Appendix H.

Adhesion or cohesion failure occurred either at the coating, adhesive, substrate, or interface between them. In all cases, there was neither purely adhesion failure nor cohesion failure, but two or more types of failure were found and irregularly distributed in the fractured areas. An average of 61% of the bonded area on smooth specimens and 64% of the bonded area on rough-sawn specimens after 2 years of exposure involved wood failure in the adhesion tests. An average of 91% of the bonded area on smooth specimens and an average of 78% of the bonded area on rough-sawn specimens after 4 years of exposure involved wood failures. Hence, the bonding strengths presented in Appendix H are not entirely the bonding strengths of the coatings but are a combination of adhesion and cohesion strength of the coatings and internal strength of the wood substrate.

The average initial bonding strength of coatings on rough-sawn surfaces (19.2 kg/cm^2) was significantly higher (41%) than the average bonding strength of coatings on smooth surfaces (13.4 kg/cm^2). However, after 4 years of exposure, the difference in bonding strengths between the smooth surface and rough-sawn surface was significantly less (19.4 kg/cm^2 versus 16.8 kg/cm^2, respectively) as shown in Appendix H. Appendix H also reveals that the bonding strengths of coatings on rough-sawn surfaces remained quite constant when examined initially, after 2 years, and after 4 years of exposure (19.2, 20.7, and 19.4, respectively). However, the bonding strength of the coatings on smooth surfaces fluctuated considerably during the same period (13.4, 20.0, and 16.8, respectively). The increase in bonding strength after weathering is probably attributed to loss of the surface active agent. There was quite a variation in bonding strength measured among the 22 systems despite the fact that 14 had the same primer.

To identify any relationship between bonding strength and coating performance on rough-sawn surfaces, correlation coefficients between initial bonding strength listed in Appendix H and performance (after 48 months of exposure) in each category listed in Tables D-4, D-8, D-12, D-16, D-20, D-24, D-28, D-32, and D-36 in Appendix D were determined, respectively. Their significance and correlation coefficients are listed in the first and second columns, respectively, in Table 4. To identify any relationship between initial bonding strength and performance on smooth surfaces, correlation coefficients between initial bonding strength listed in Appendix H and performance (after 48 months of exposure) in each category listed in the same tables as above were also determined, respectively; their significance and correlation coefficients are listed in the third and fourth columns, respectively, in Table 4. To determine the correlation between bonding strength and performance of coatings on smooth and rough-sawn surfaces after 4 years of exposure, correlation coefficients between bonding strength listed in Appendix H and performance in each category listed in the same tables as above were determined. Correlation coefficients and their significance are listed in the fifth through eighth columns of Table 4.

Tests of significance on these correlation coefficients listed in Table 4 showed that there is no significant correlation between initial bonding strength and coating performance after 4 years of exposure in each category. The correlation coefficients listed in Table 4 failed to meet the critical value, a correlation coefficient of 0.42 at the 95% confidence level, except correlation coefficients obtained between initial bonding strength on smooth surfaces and chalking after 4 years of exposure (0.46), which indicates that there is significant correlation between initial bonding strength and chalking of the exposed coatings.

Contrary to the poor correlation exhibited between initial bonding strength and coating performance, bonding strength after 4 years of exposure correlated significantly well with coating performance after 4 years of exposure in many categories as shown in Table 4. Among the coatings on the rough-sawn plywood, correlation between bonding strength versus general protection, discoloration, chalking, checking, cracking, and erosion was either significant (95% confidence level) or highly significant (99% confidence level) as shown in Table 4. Among the coatings on the smooth plywood, bonding strength correlated well with general protection, discoloration, cracking, and erosion as shown in Table 4. There was no correlation between bonding strength and blistering and mildew because no blisters or mildew appeared during the 4 years of exposure.

To analyze the correlation between the average of initial bonding strength (average of values for smooth and rough-sawn surfaces for each coating system) listed in Appendix H and overall performance listed in Table 2, correlation coefficients between them were determined. Similarly, correlation coefficients between average bonding strength of coatings exposed for 4 years listed in Appendix H and overall performance listed in Table 2 were determined. These correlation coefficients are listed in Table 5.

Tests of significance on correlation coefficients listed in Table 5 failed to show that there is significant correlation between initial bonding strength and overall coating performance. The correlation coefficients obtained were far below the critical value of 0.42 at the 95% confidence level. However, the correlation coefficient obtained between bonding strength after 4 years of exposure and overall performance (0.537) indicated that there is highly significant correlation between them.

Thus, among 13 coating systems that were ranked 1st to 13th (scored 8 or above) in Table 2, 7 were among those of "good adhesion" (20 kg/cm^2 or better); among the 9 remaining coating systems that were ranked 14th to 22nd (scored below 8), none were among those of "good adhesion." Poor correlation between initial bonding strength and overall coating performance suggests that initial adhesion values of coatings on wood are not useful data to predict the ultimate performance of the coatings. However, further examination of the performance scores listed in Table 2 and the bonding strengths listed in Appendix H suggests that the minimum initial adhesion strength of coatings on plywood should be 12.0 kg/cm^2 to attain a performance score of fair or better (8.0 or better) for about 4 years.

Coating Penetration

Penetration results are tabulated and summarized in Appendix I. They indicate that the coatings penetrated deeper into rough-sawn surfaces than smooth surfaces, 144.4 μm versus 105.9 μm, respectively. Seventeen of the 22 coating systems penetrated deeper into rough-sawn surfaces, while the other 5 systems penetrated deeper into smooth surfaces. There was a wide range of penetration depths among the 22 coating systems despite the fact that 14 had the same primer.

The correlation between penetration listed in Appendix I and bonding strength of the coatings listed in Appendix H was analyzed. The analysis indicated that there was poor correlation between measured penetration and bonding strength. Deeper penetration did not result in greater bonding strength.

To determine if there was any correlation between coating penetration and performance on rough-sawn and smooth surfaces, correlation coefficients between penetration listed in Appendix I and fourth-year overall performance were determined. The overall performance ratings of coatings on rough-sawn or smooth surfaces were computed from the 48-month ratings listed in Tables D-4, D-8, D-12, D-16, D-20, D-24, D-28, D-32, and D-36 of Appendix D in the same way Table 2 was prepared except that ratings on rough-sawn and smooth surfaces were used rather than the average of the two ratings.

Tests of significance on the correlation coefficients listed in Table 6 indicate there is significant correlation between penetration of coating into rough-sawn wood and overall coating performance. The correlation coefficient between penetration into smooth wood and overall coating performance (0.33) indicated that there was no correlation between them because it failed to meet the critical value, a correlation coefficient of 0.422 at the 95% confidence level.

The correlation coefficient obtained between average penetration (average of rough and smooth surface) and average overall coating performance (0.43) listed in Table 2 indicates that there is significant correlation between them. Thus, among the 13 coating systems that were ranked 1st to 13th (scored 8 or better) in Table 2, 10 were among those of "good penetration" (125 μm or better); among the 9 remaining coating systems that were ranked 14th to 22nd, only 3 were among those of "good penetration."

The solvent-type alkyd coatings, Systems 1, 2, and 3, penetrated much less than the latex coating systems, as shown in Appendix I. These same systems also performed more poorly than the latex coating systems (see Table 2 and Appendix I).

A significant correlation between coating penetration and performance suggests that the coating penetration value can be a useful tool to predict ultimate performance of the coating, and it warrants further study to improve techniques for predicting coating performance.

SUMMARY OF FINDINGS

1. After 4 years of field exposure, latex/latex coating systems performed significantly better than latex/alkyd, alkyd/latex, or alkyd/alkyd coating systems.

2. Statistical analysis indicated significant correlation between adhesion strength of the field-exposed coatings and field performance.

3. Statistical analysis indicated significant correlation between penetration of coating into rough-sawn wood and coating field performance.

4. Coating systems applied over rough-sawn surfaces performed significantly better than those same coating systems applied over smooth surfaces in all performance categories.

5. Among the 22 coating systems tested, Sinclair products ranked first, second, and fourth and SUNCO was tied at second. UCAR ranked fifth, seventh, and eighth.

6. The specification paints contained significantly higher concentrations of pigments and significantly lower concentrations of nonvolatile resins than most of the other proprietary products tested.

7. The proprietary paints performed quite well on plywood for 4 years, while the specification coatings did not perform well. However, the specification paints were obtained from a single source; therefore, it cannot be concluded in general that proprietary products can be always better than specification paints. Also, they did not conform to specification.

CONCLUSIONS

1. Latex coating systems can be satisfactorily substituted for traditional solvent-type alkyd coating systems to protect wood substrates.

2. The initial bonding strength of a coating on wood is useful in determining whether the value meets the minimum required to attain a fair or acceptable level of performance.

3. The initial bonding strength of latex coatings for plywood should be 12.0 kg/cm^2 or higher to attain fair or better performance for about 4 years.

4. The results indicate that it should be possible to predict ultimate performance of the coating in the field from the penetration data.

5. The minimum penetration of a latex coating into the wood surface should be 125 µm or deeper to attain fair or better performance for about 4 years.

RECOMMENDATIONS

1. Latex coating systems that meet the product criteria listed in Tables G-1, G-2, and G-3 of Appendix G should be used as substitutes for solvent-type coatings where solvent-type coatings are prohibited by

environmental regulations and elsewhere to minimize the number of different products purchased. This will simplify procurement, reduce costs, and result in a faster consumption of stored paints.

2. The wood surface to be protected should be rough sawn rather than smooth, as appropriate for the desired appearance, for better protection by latex coatings.

3. The correlation between bonding strength of artificially weathered coatings on wood and field performance and between coating penetration and field performance should be investigated to develop quality assurance tests for coatings to ensure satisfactory coating performance.

FUTURE WORK

1. A user data package (UDP) for environmentally acceptable coatings for wood will be prepared for use by Navy activities in all environments.

2. Source variation of coating materials and acceptable variation limits will be determined to investigate the capability of paint suppliers, located in different geographical areas, to reproduce the same paint as specified.

3. Quality assurance tests will be developed to ensure performance of coatings procured.

REFERENCES

1. Naval Facilities Engineering Command. Public Work Center Activation Manual, NAVFAC P-319: Statistical tables of military real properties. Alexandria, Va., Sep 1984.

2. Naval Civil Engineering Laboratory. Technical Memorandum M-52-81-07: Alternative building materials for reducing maintenance and repair cost at Naval shore activities, by T. Roe, Jr. and S.R. Conklin. Port Hueneme, Calif., Dec 1981.

3. M.C. Hendry. "Industrial maintenance coatings after CARB," paper presented at the National Association of Corrosion Engineers 1979 Western Regional Conference, San Francisco, Calif., 9-11 Oct 1979.

4. L. Dill. "No contest in So. Cal. Rule 1113 showdown; Paint industry loses," Western Paint and Decorating, Sep 1983.

5. H.E. Payne. Organic coating technology. New York, N.Y., John Wiley and Sons, Inc., 1961, pp 717-720, 979-982.

Table 1. Identification of Coating Systems

System Number	Primer		Topcoat	
	Specification	Type	Specification	Type
1	MIL-P-28582	Alkyd	TT-E-529	Alkyd
2	MIL-P-28582	Alkyd	TT-P-19	Latex
3	MIL-P-28582	Alkyd	TT-P-1510	Latex
4	SUNCO	Latex	SUNCO	Latex
5	TT-P-001984	Latex	TT-E-529	Alkyd
6	TT-P-001984	Latex	TT-P-19	Latex
7	TT-P-001984	Latex	TT-P-1510	Latex
8	TT-P-001984	Latex	TT-P-96	Latex
9	TT-P-001984	Latex	Ameritone W9900	Latex
10	TT-P-001984	Latex	UCAR 19-92-A	Latex
11	TT-P-001984	Latex	UCAR 19-92-B	Latex
12	TT-P-001984	Latex	UCAR 19-92-C	Latex
13	TT-P-001984	Latex	UCAR 19-93-A	Latex
14	Sinclair AP8-11	Latex	Sinclair 4800	Latex
15	TT-P-001984	Latex	Standard Brands F6674-1	Latex
16	TT-P-001984	Latex	Standard Brands F6674-2	Latex
17	Sinclair AP8-11	Latex	Sinclair 4400	Latex
18	Sinclair AP8-11	Latex	Sinclair 1300	Latex
19	TT-P-001984	Latex	Standard Brands F6674-3	Latex
20	TT-P-001984	Latex	Standard Brands F6674-4	Latex
21	TT-P-001984	Latex	Standard Brands F6674-5	Latex
22	AMOCO WS-549	Alkyd[a]	AMOCO WS-549	Alkyd[a]

[a]Water-reducible alkyd.

Table 2. Overall Performance Ranking and Scores for Coating Systems

Rank	System Number	Score	Primer		Topcoat	
			Specification	Type	Specification	Type
1	18	9.60	Sinclair AP8-11	Latex	Sinclair 1300	Latex
2	4	9.54	SUNCO	Latex	SUNCO	Latex
2	17	9.54	Sinclair AP8-11	Latex	Sinclair 4400	Latex
4	14	9.46	Sinclair AP8-11	Latex	Sinclair 4800	Latex
5	13	9.44	TT-P-001984	Latex	UCAR 19-93-A	Latex
6	19	9.31	TT-P-001984	Latex	Standard Brands F6674-3	Latex
7	10	9.24	TT-P-001984	Latex	UCAR 19-92-A	Latex
8	12	9.20	TT-P-001984	Latex	UCAR 19-92-C	Latex
9	16	9.17	TT-P-001984	Latex	Standard Brands F6674-2	Latex
10	21	9.04	TT-P-001984	Latex	Standard Brands F6674-5	Latex
11	15	8.72	TT-P-001984	Latex	Standard Brands F6674-1	Latex
12	20	8.63	TT-P-001984	Latex	Standard Brands F6674-4	Latex
13	11	8.18	TT-P-001984	Latex	UCAR 19-92-B	Latex
14	9	7.98	TT-P-001984	Latex	Ameritone W9900	Latex
15	2	7.37	MIL-P-28582	Alkyd	TT-P-19	Latex
16	3	7.28	MIL-P-28582	Alkyd	TT-P-1510	Latex
16	7	7.28	TT-P-001984	Latex	TT-P-1510	Latex
18	5	7.20	TT-P-001984	Latex	TT-E-529	Alkyd
19	6	7.07	TT-P-001984	Latex	TT-P-19	Latex
20	8	7.02	TT-P-001984	Latex	TT-P-96	Latex
21	1	6.52	MIL-P-28582	Alkyd	TT-E-529	Alkyd
22	22	6.31	Amoco WS-549	Alkyd[a]	Amoco WS-549	Alkyd[a]

[a]Water-reducible alkyd.

Table 3. Averages of Coating Data Based on Sources

Paint Source	Weight/ Gallons (lb/gal)	Viscosity (kg)	Pigment (%)	Total Solids (%)	Nonvolatile Vehicle (NVV) (%)	% Pigment/ % NVV
Specifications	11.0	91	34.5	55.8	21.2	1.6
UCAR	10.7	88	22.6	58.9	36.3	0.62
Sinclair	10.7	84	27.2	48.9	21.8	0.55
Standard Brands	10.7	85	27.3	52.4	25.1	1.08
Average	10.8	87	27.9	54.0	26.0	1.07

Table 4. Test of Significance[a] of Correlation Coefficients Between Bonding Strength and Coating Performance

Performance Category	Initial Bonding Strength Versus Field Performance				Bonding Strength After 4 Years Versus Field Performance			
	Rough-Sawn Plywood		Smooth Plywood		Rough-Sawn Plywood		Smooth Plywood	
	Significance	Correlation Coefficient	Significance	Correlation Coefficient	Significance	Correlation Coefficient	Significance	Correlation Coefficient
General Protection	No	0.26	No	0.09	Yes	0.53	Yes	0.48
Discoloration	No	0.25	No	0.02	Yes	0.54	Yes	0.45
Chalking	No	0.29	Yes	0.46	Yes	0.54	No	0.34
Checking	No	0.28	No	0.30	Yes	0.46	No	0.39
Cracking	No	0.25	No	0.32	Yes	0.51	Yes	0.49
Flaking	No	0.01	No	0.10	No	0.30	No	0.29
Blistering	No	0.00	No	0.00	No	0.00	No	0.00
Erosion	No	0.04	No	0.23	Yes	0.45	Yes	0.48
Mildew	No	0.00	No	0.00	No	0.00	No	0.00

[a]Significance level at 95% confidence level = 0.42.

Table 5. Test of Significance[a] of Correlation Coefficients Between Bonding Strength and Overall Performance of Coatings

Item	Bonding Strength	
	Initial	After 4 Years
Overall Performance	0.08	0.537
Significance	none	significant

[a]Significance level at 99% confidence level = 0.53.

Table 6. Test of Significance of Correlation Coefficients Between Coating Penetration and Overall Coating Performance

Surface	Penetration Versus Overall Performance (4 Years)
Rough-Sawn	0.42[a]
Smooth	0.33
Average	0.43[a]

[a]Significant at 95% confidence level (critical value = 0.42).

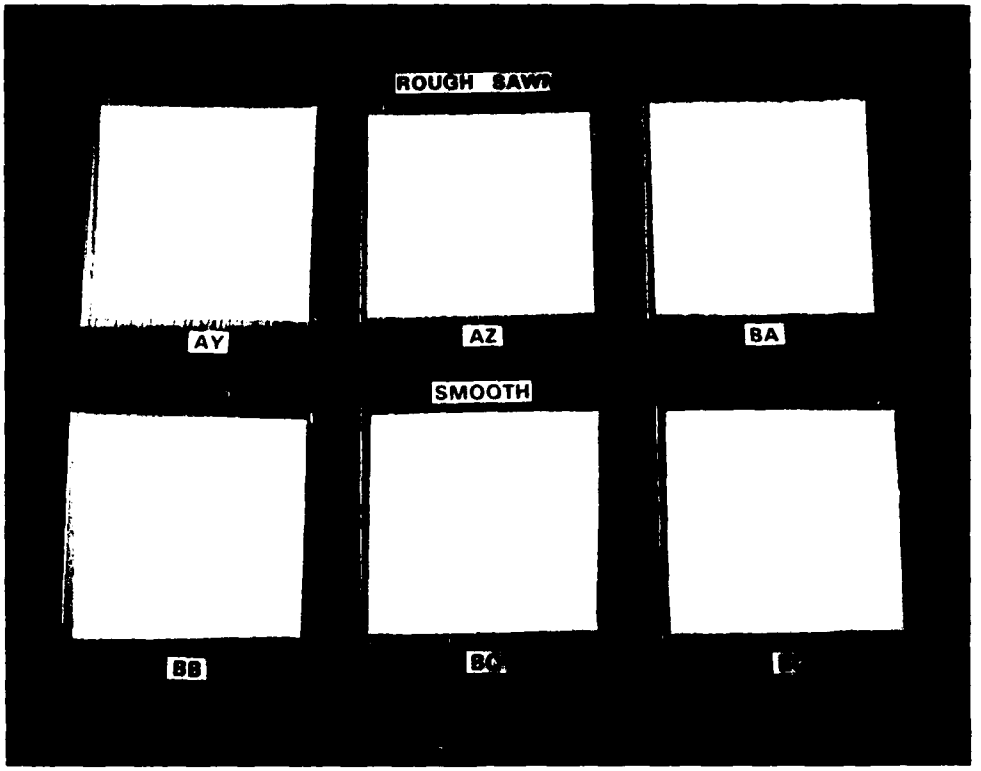

Figure 1. Rough-sawn and smooth plywood coated in triplicates.

Figure 2. Coated plywood panels exposed at the Kwajalein marine atmospheric exposure test site.

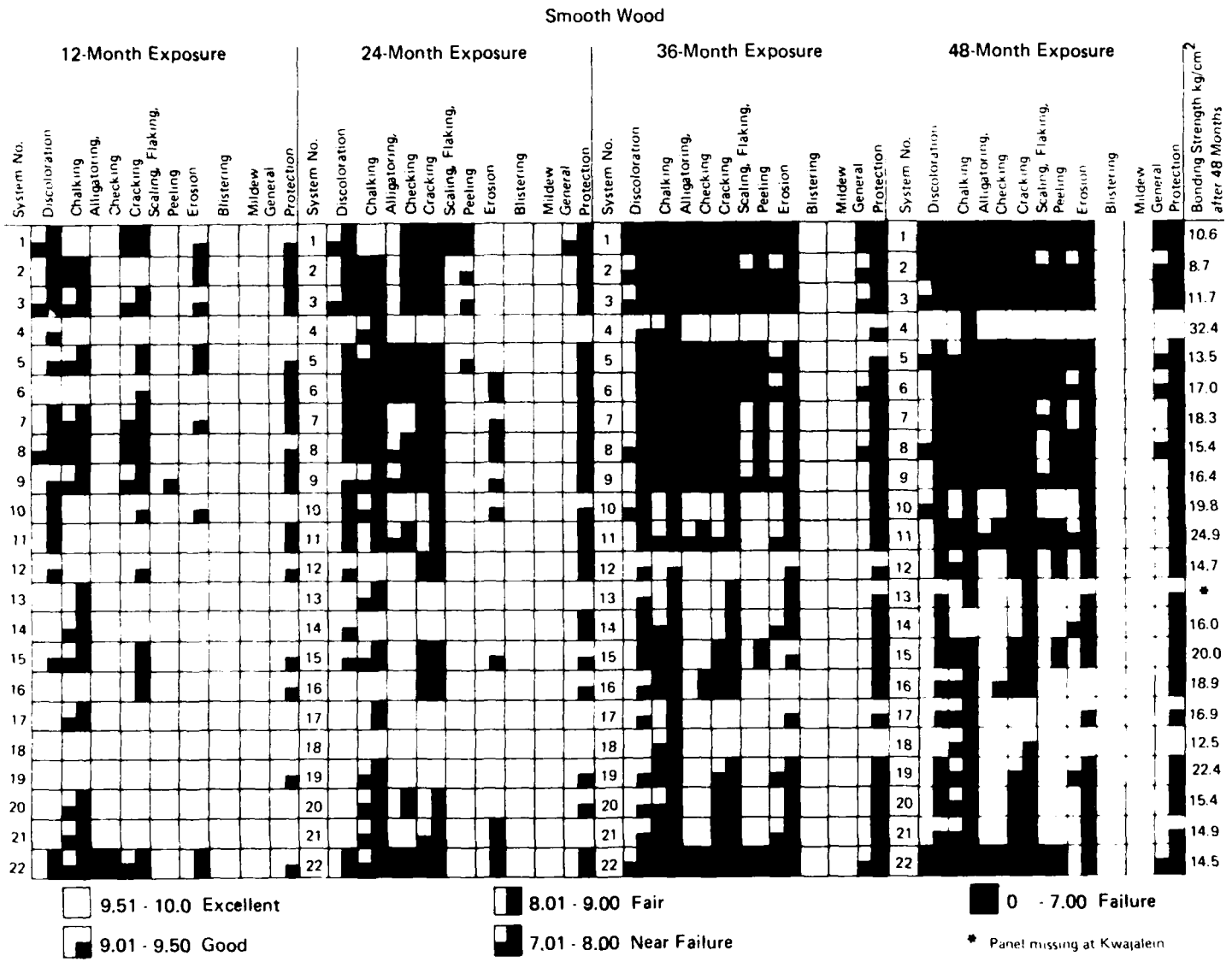

Figure 3. Relative performance of the coating systems on smooth wood over the past 4 years of exposure and their bonding strength after 48 months.

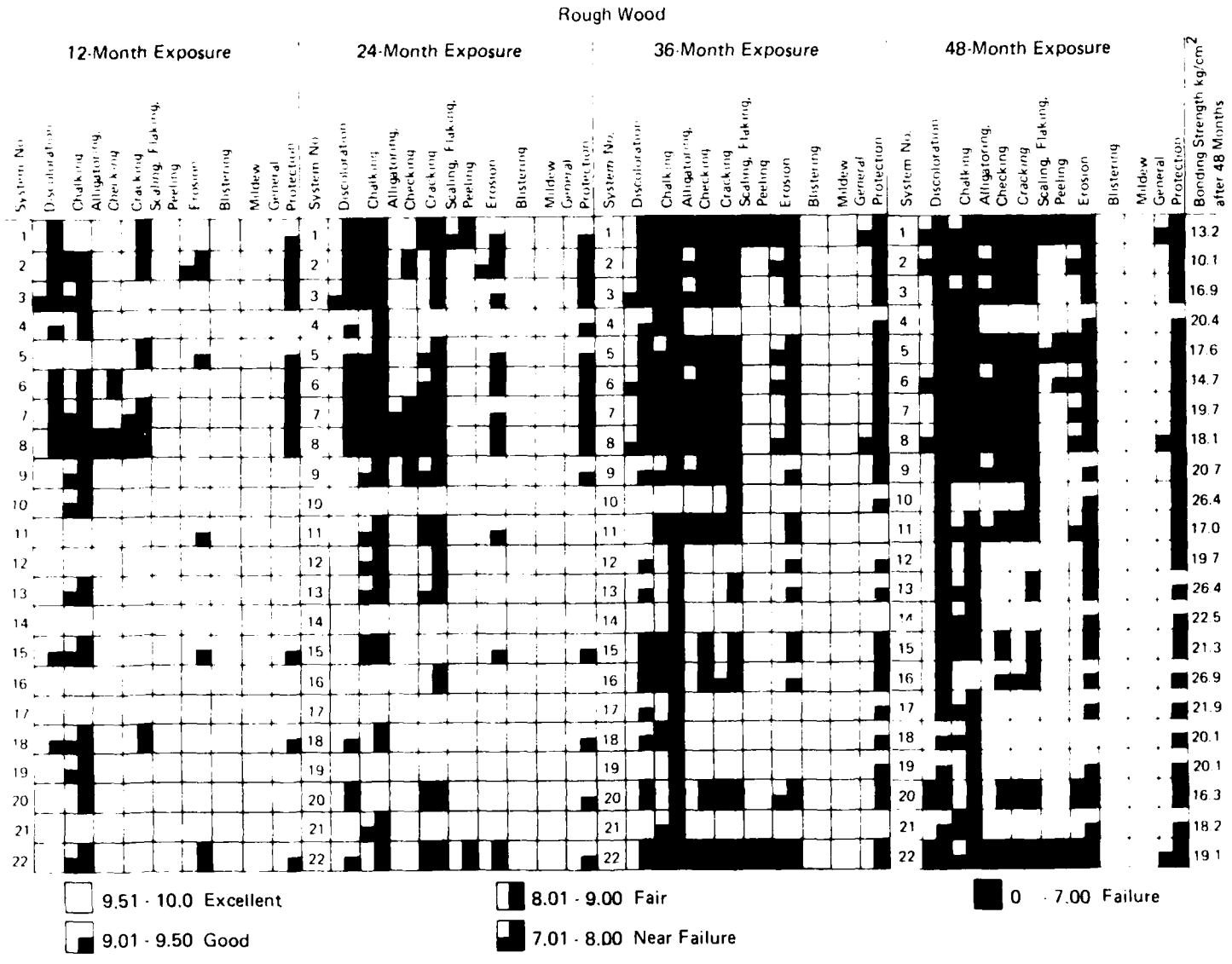

Figure 4. Relative performance of the coating systems on rough-sawn wood over the past 4 years of exposure and their bonding strength after 48 months.

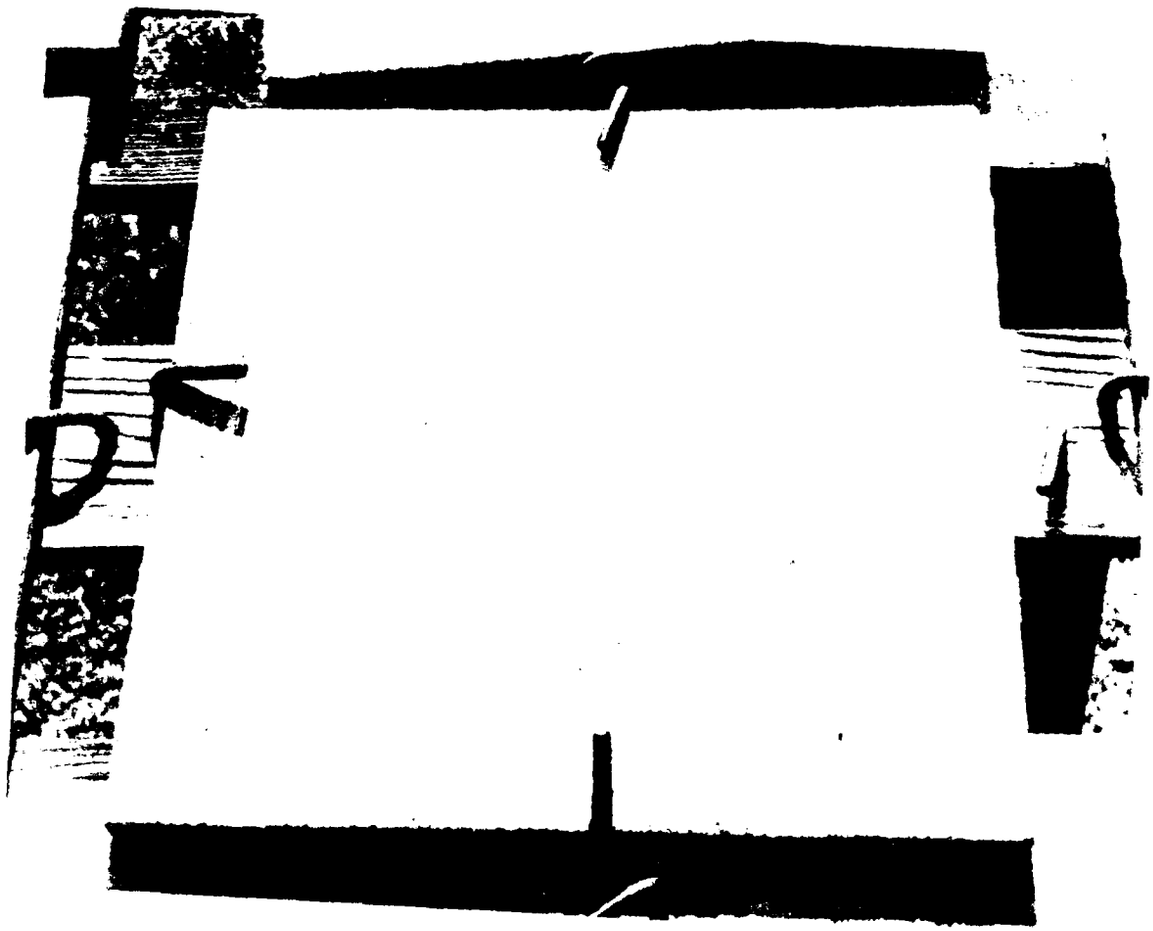

Figure 5. Flaking and cracking of Government specification coating on plywood after 4 years of exposure.

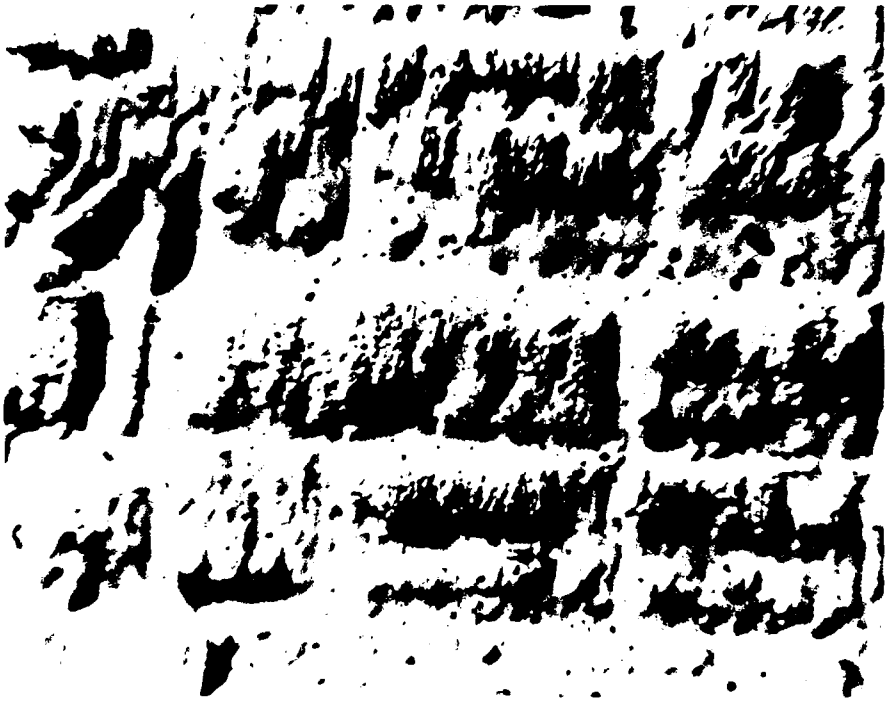

Figure 6. No checking or cracking on proprietary latex coating, System 21, after 2 years of exposure at Kwajalein (x10 magnification).

Figure 7. Checking and cracking on latex Government specification paint, TT-P-96, after 2 years of exposure at Kwajalein (x10 magnification).

Appendix A

FORMULATIONS OF COATINGS*

Ingredients	Weight (lb)	Amount
TT-P-19C		
Acrylic Resin (AC388)	284.5	31.5 gal
Water	139.6	16.75 gal
Titanium Dioxide RUNA	50.0	1.5 gal
Talc 10-40	80.0	
Hi Sil. 422 (Clay)	30.0	1.4 gal
Vicron 45-3	80.0	
Kelcin 1081 (Wetting Agent)		38 oz
Ethylene Glycol		1.83 oz
9N9 (Anionic Wetting Agent)		19 oz
BYK (Film Hardening Agent)		12 oz
PMA (Phenylmercuric Acetate)		2.5 oz
KTPP (Potassium Tripolyphosphate)	0.75	
Methocel J 12HS (Thickening Agent)	3.0	
Ammonia		12 oz
N.D.W. (Defoamer)		9 oz

*Formulations as supplied by paint manufacturer. Some of the proprietary product suppliers did not provide formulations.

Ingredients	Weight (lb)	Amount
TT-E-529C		
Alkyd Resin Type III TT-R-266D	485	
Talc 20-30	180	
Wetting Agent	2	
Mineral Spirits	140	
CR 820 Titanium Dioxide	270	
Cobalt Drier	2	
Lead Drier	4	
Calcium Drier	4	
Antiskinning Agent	11	
TT-P-1510		
Vinyl Acrylic Resin	283	31 gal
Water	283	34 gal
Zinc Oxide	50	
Titanium Dioxide RUNA	250	7.3 gal
Talc	100	
Hi Sil. 422 (Clay)	50	
PVO 44-0 (Veg Oil)	120	
Kelcin 1081 (Wetting Agent)	4	
9N9 (Anionic Wetting Agent	2	
N.D.W. (Defoamer)	4	
KTPP (Potassium Triphosphate)	7	
Ammonia		20 oz
Ethylene Glycol	17	
Lead Drier	8	
Cobalt Drier	2	
Manganese Drier	2	

Ingredients	Weight (lb)	Amount
TT-P-96 Type I		
Vinyl Acrylic Resin	273	30 gal
Water	407	48.5 gal
Titanium Dioxide RUNA	250	7.3 gal
Clay	50	2.3 gal
Hi Sil. 422	50	2.3 gal
pH Stabilizer	50	2.3 gal
Talc 20-30	50	2.3 gal
Kelcin 1081 (Wetting Agent)	4	0.5 gal
Tarnol 731 (Wetting Agent)	4	0.5 gal
Ethylene Glycol	15.6	2 gal
N.D.W. (Defoamer)	3.9	45 oz
9N9 (Anionic Wetting Agent)	2.2	0.25 gal
Texanol (Coalescing Aid)	10.3	1.25 gal
PMA (Phenylmercuric Acetate)		2.5 oz
Methocel J 12HS (Thickening Agent)	7	
KTPP (Potassium Tripolyphosphate)	1	25 oz
Ammonia		25 oz
MIL-P-28582 Primer		
Alkyd Resin (Type I, Class B, TT-R-266D)	210	
Wetting Agent	4	0.25 gal
Titanium Dioxide RUNA	215	
Talc 20-30	250	
Bentone #34	3	
Mineral Spirits	16	
Varkyd 57-38 Resin	299	
Fungicide	5	
Cobalt Drier	2	
Manganese Drier	2	
Lead Drier	4	
Antiskinning Agent	2	
Mineral Spirits	98	

Ingredients	Weight (lb)	Amount
TT-P-001984		
Vinyl Acrylic Resin	318.5	35 gal
Water	467.0	56 gal
Texanol (Coalescing Aid)		1.75 gal
Ethylene Glycol		1.75 gal
Kelcin 1081 (Wetting Agent)		0.50 gal
N.D.W. Defoamer		45 oz
9N9 (Anionic Wetting Agent)		32 oz
PMA (Phenylmercuric Acetate)		2.5 oz
KTPP (Potassium Tripolyphosphate)	1	
Methocel J 12HS	7	
Ammonia		15 oz
Titanium Dioxide RUNA	150	
Vicron 15-15	50	
ASP 800	50	
Mica 325	50	
pH Stabilizer	50	
Amoco WS-549		
Resin WS-549 HRM	328	
Ammonium Hydroxide 28%	20	
Water	533.75	
Drier Accelerator	1.0	
Anti-Skinning Agent	1.0	
Flow Agent	0.5	
Titanium Dioxide R-900	221.0	
Organic Titanate	15.0	

Ingredients	Weight (lb)	Amount
UCAR 19-92-A		
UCAR Acrylic 503 Resin	614	67.0 gal
Texigel 23-555	26.25	3.0 gal
Tergital NP-10	2.25	0.25 gal
Nalco 2300	0.5	0.05 gal
Nalco 2303	4.5	0.56 gal
Aqueous Ammonia (28%	2.0	0.25 gal
Grind	410.25	26.40 gal
Acrysol RM-3	17.5	2.0 gal
Water	4.25	0.5 gal
Propylene Glycol	13.0	1.50 gal
UCAR 19-92-B		
UCAR Acrylic 351 Resin	532	59.0 gal
Texigel 23-555	26.25	3.0 gal
Tergitol NP-10	2.25	0.25 gal
Nalco 2300	0.5	0.06 gal
Nalco 2303	4.5	0.56 gal
Aqueous Ammonia (28%)	2.0	0.25 gal
Grind	410.25	26.40 gal
Acrysol RM-3	17.5	2.0 gal
Water	83.0	10.0 gal
Propylene Glycol	13.0	1.0 gal

Ingredients	Weight (lb)	Amount
UCAR 19-92-C		
UCAR Acrylic 515 Resin	672.0	74.0 gal
Texigel 23-555	26.25	3.0 gal
Tergitol NP-10	2.25	0.25 gal
Nalco 2300	0.5	0.06 gal
Nalco 2303	4.5	0.56 gal
Aqueous Ammonia (28%)	2.0	0.25 gal
Grind	410.25	26.40 gal
Acrysol RM-3	17.5	2.0 gal
UCAR 19-93-A		
UCAR Acrylic 503 Resin	596	65.0 gal
Texigel 23-555	52.5	6.0 gal
Nalco 2300	0.5	0.06 gal
Nalco 2303	4.5	0.56 gal
Aqueous Ammonia (28%)	2.0	0.25 gal
Grind	391.625	22.17 gal
BYK 301	2.0	0.25 gal
Butyl Cellosolve	15.0	2.0
Water	37.5	4.5 gal

Appendix B

LABORATORY ANALYSES OF COATINGS INVESTIGATED

Paint	Weight/Gallon (lb/gal)	Viscosity (KU)	Pigment (% by wt)	Total Solids (% by wt)	Nonvolatile Resin (% by wt)	Condition in Container
MIL-P-25852	11.83	90	54.60	72.56	17.96	Good
TT-E-529	10.04	74	34.33	61.33	27.00	Good
TT-P-19	11.00	103	32.53	54.52	21.99	Good
TT-P-1510	11.13	95	32.86	52.15	19.29	Cood
SUNCO	11.90	103	39.46	66.31	26.85	Good
TT-P-001984	10.20	90	20.77	40.85	20.08	Good
TT-P-96	11.93	91	38.15	55.03	16.88	Good
Ameritone W9900	10.03	86	24.65	47.18	22.53	Good
UCAR 19-92-A	10.7	100	22.57	59.4	36.83	Good
UCAR 19-92-B	10.5	82	22.30	58.6	36.30	Good
UCAR 19-92-C	10.6	100	21.24	57.2	35.96	Good
UCAR 19-93-A	10.9	68	24.28	60.3	36.82	Good
Sinclair AP8-11	10.49	81	23.46	53.14	29.68	Good
Sinclair 4800	10.61	77	24.42	48.66	24.24	Good
Sinclair 4400	10.34	82	22.77	46.86	24.09	Good
Sinclair 1300	11.07	92	34.49	51.31	16.82	Good
Standard Brands F6674-1	12.26	86	37.30	61.44	24.14	Good
Standard Brands F6674-2	10.12	89	30.78	55.85	25.07	Good
Standard Brands F6674-3	10.81	82	24.19	52.31	28.12	Good
Standard Brands F6674-4	10.07	88	17.71	37.91	20.20	Good
Standard Brands F6674-5	9.99	80	26.40	54.28	27.88	Good
Amoco WS-549	9.98	72	18.95	43.64	24.69	Good

Appendix C

SOURCES OF MATERIALS

Paint	Manufacturer
Amoco, White Enamel, WS-549	Amoco Chemical Corporation Naperville, IL 60540
MIL-P-28582 TT-E-529 TT-P-19 TT-P-1510 TT-P-96 TT-P-001984	Pro-Line Paint Manufacturing Co. San Diego, CA 92113
Ameritone, W9900 White	Ameritone Paint Corporation Long Beach, CA 90801
UCAR 19-92-A 19-92-B 19-92-C 19-93-A	Union Carbide Corporation Torrance, CA 90503
Sinclair AP8-11 4800 4400 1300	Sinclair Paints Los Angeles, CA 90023
SUNCO	SUNCO Products Los Angeles, CA 90032
Standard Brands F6674-1 F6674-2 F6674-3 F6674-4 F6674-5	Standard Brands Paint Co. Torrance, CA 90509

Appendix D

MARINE ATMOSPHERIC EXPOSURE RATINGS OF WOOD PANELS

Table D-1. General Protection (after 6 and 12 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
6 Months				12 Months			
1	10.00	9.85	9.93	1	9.15	9.30	9.23
2	10.00	9.85	9.93	2	9.00	9.00	9.00
3	9.85	9.85	9.85	3	9.00	8.85	8.93
4	10.00	10.00	10.00	4	9.50	9.50	9.50
5	10.00	10.00	10.00	5	9.30	9.65	9.48
6	10.00	10.00	10.00	6	9.00	9.00	9.00
7	10.00	9.85	9.93	7	9.15	9.00	9.08
8	9.70	9.00	9.35	8	9.30	8.70	9.00
9	9.70	9.70	9.70	9	8.65	9.70	9.18
10	10.00	10.00	10.00	10	9.50	9.70	9.60
11	9.85	9.85	9.85	11	9.15	9.50	9.33
12	10.00	10.00	10.00	12	9.50	9.85	9.68
13	10.00	10.00	10.00	13	9.70	9.50	9.60
14	10.00	10.00	10.00	14	9.70	9.70	9.70
15	9.50	10.00	9.75	15	9.00	9.65	9.33
16	10.00	10.00	10.00	16	9.50	10.00	9.75
17	10.00	10.00	10.00	17	9.50	9.85	9.68
18	10.00	10.00	10.00	18	9.70	9.50	9.60
19	10.00	10.00	10.00	19	9.50	9.70	9.60
20	10.00	10.00	10.00	20	9.70	9.85	9.78
21	10.00	10.00	10.00	21	9.50	9.85	9.68
22	9.70	9.35	9.53	22	9.30	9.15	9.23
Overall average	9.92	9.88	9.90		9.33	9.48	9.40

Table D-2. General Protection (after 18 and 24 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
18 Months				24 Months			
1	8.83	9.00	8.92	1	8.33	9.17	8.75
2	8.83	9.00	8.92	2	8.83	8.83	8.83
3	8.83	8.83	8.83	3	8.66	8.83	8.75
4	9.50	9.50	9.50	4	9.50	9.33	9.41
5	9.00	9.33	9.17	5	8.83	9.33	9.08
6	9.00	9.00	9.00	6	8.66	8.83	8.75
7	9.17	9.00	9.08	7	9.17	9.00	9.08
8	9.17	8.66	8.91	8	9.00	8.67	8.83
9	9.00	9.33	9.17	9	9.00	9.17	9.08
10	9.50	9.66	9.58	10	9.33	9.66	9.50
11	9.17	9.50	9.33	11	9.17	9.50	9.33
12	9.50	9.66	9.58	12	9.33	9.66	9.50
13	9.66	9.50	9.58	13	9.50	9.50	9.50
14	9.33	9.83	9.58	14	9.17	9.83	9.50
15	9.00	9.50	9.25	15	8.67	9.50	9.08
16	9.33	9.83	9.58	16	9.33	9.83	9.58
17	9.50	9.83	9.66	17	9.50	9.83	9.66
18	9.66	9.50	9.58	18	9.66	9.50	9.58
19	9.50	9.66	9.58	19	9.50	9.83	9.66
20	9.83	9.83	9.83	20	9.50	9.50	9.50
21	9.33	9.66	9.50	21	9.33	9.83	9.58
22	9.00	9.00	9.00	22	9.00	9.00	9.00
Overall average	9.25	9.39	9.32		9.13	9.37	9.25

Table D-3. General Protection (after 30 and 36 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
30 Months				36 Months			
1	6.66	8.33	7.50	1	6.00	8.00	7.00
2	8.00	8.66	8.33	2	8.00	8.66	8.33
3	8.00	8.66	8.33	3	7.66	8.66	8.16
4	9.33	9.33	9.33	4	9.33	9.33	9.33
5	8.66	9.00	8.83	5	9.33	9.00	9.17
6	8.33	9.00	8.67	6	8.00	8.66	8.33
7	8.66	9.00	8.83	7	8.66	8.66	8.66
8	8.00	8.00	8.00	8	8.00	8.00	8.00
9	8.66	9.33	9.00	9	8.66	9.00	8.83
10	9.33	9.33	9.33	10	9.00	9.33	9.17
11	9.00	9.66	9.33	11	8.66	9.66	9.16
12	9.33	9.33	9.33	12	9.33	9.33	9.33
13	9.66	9.66	9.66	13	9.33	9.33	9.33
14	9.00	10.00	9.50	14	8.66	9.66	9.16
15	9.33	9.33	9.33	15	9.00	9.00	9.00
16	8.66	9.00	8.83	16	8.66	9.00	8.83
17	9.66	9.66	9.66	17	9.33	9.33	9.33
18	9.66	9.33	9.50	18	9.66	9.33	9.50
19	9.00	9.66	9.33	19	9.00	9.33	9.17
20	9.00	9.00	9.00	20	8.66	8.66	8.66
21	9.33	10.00	9.67	21	9.00	9.66	9.33
2.	8.00	8.66	8.33	22	8.00	8.33	8.17
O erall average	8.78	9.18	8.98		8.63	9.00	8.81

Table D-4. General Protection (after 42 and 48 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
42 Months				48 Months			
1	7.00	8.00	7.50	1	6.00	7.66	6.83
2	8.00	8.66	8.33	2	8.00	8.66	8.33
3	7.33	8.66	8.00	3	7.00	8.66	7.83
4	9.66	9.33	9.50	4	9.66	9.33	9.50
5	8.00	9.00	8.50	5	7.66	8.66	8.16
6	8.00	8.66	8.33	6	7.66	8.66	8.16
7	8.66	8.66	8.66	7	8.66	8.33	8.50
8	8.00	8.00	8.00	8	8.00	8.00	8.00
9	8.66	9.00	8.83	9	8.33	9.00	8.67
10	9.00	9.00	9.00	10	8.66	9.00	8.83
11	8.66	9.00	8.83	11	8.33	9.00	8.67
12	9.00	9.00	9.00	12	8.66	9.00	8.83
13	9.33	9.33	9.33	13	9.33	9.33	9.33
14	9.00	9.66	9.33	14	9.00	9.33	9.17
15	9.00	9.33	9.17	15	9.00	9.00	9.00
16	9.00	9.00	9.00	16	9.00	9.33	9.17
17	9.33	9.33	9.33	17	9.33	9.33	9.33
18	9.66	9.33	9.50	18	9.77	9.33	9.55
19	8.66	9.33	9.00	19	8.66	9.33	9.00
20	9.00	8.66	8.83	20	9.00	8.33	8.67
21	9.33	9.66	9.50	21	9.33	9.33	9.33
22	7.66	7.66	7.66	22	8.00	7.66	7.83
Overall average	8.63	8.92	8.78		8.50	8.83	8.67

Table D-5. Discoloration (after 6 and 12 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
6 Months				12 Months			
1	10.00	9.50	9.75	1	8.50	9.50	9.00
2	10.00	10.00	10.00	2	8.85	9.00	8.93
3	9.50	10.00	9.75	3	8.35	8.00	8.18
4	10.00	10.00	10.00	4	9.30	9.50	9.40
5	10.00	9.50	9.75	5	9.30	9.85	9.58
6	10.00	10.00	10.00	6	9.50	9.00	9.25
7	10.00	9.50	9.75	7	8.80	9.00	8.90
8	9.50	8.50	9.00	8	8.85	8.35	8.60
9	10.00	9.65	9.83	9	9.50	9.50	9.50
10	10.00	10.00	10.00	10	9.50	9.85	9.68
11	10.00	9.50	9.75	11	9.35	9.50	9.43
12	10.00	10.00	10.00	12	9.50	9.85	9.68
13	10.00	10.00	10.00	13	9.85	9.70	9.78
14	10.00	10.00	10.00	14	9.70	9.85	9.78
15	10.00	10.00	10.00	15	8.65	9.65	9.15
16	10.00	10.00	10.00	16	9.70	9.85	9.78
17	10.00	10.00	10.00	17	9.70	9.70	9.70
18	10.00	10.00	10.00	18	9.70	9.30	9.50
19	10.00	10.00	10.00	19	9.85	9.85	9.85
20	10.00	10.00	10.00	20	9.70	9.85	9.78
21	10.00	10.00	10.00	21	9.35	10.00	9.68
22	9.00	9.50	9.25	22	8.85	9.35	9.10
Overall average	9.91	9.80	9.86		9.29	9.45	9.37

Table D-6. Discoloration (after 18 and 24 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
18 Months				24 Months			
1	8.50	9.17	8.83	1	8.50	9.00	8.75
2	9.00	8.83	8.92	2	8.83	8.66	8.75
3	8.33	8.00	8.17	3	8.33	8.00	8.17
4	9.50	9.50	9.50	4	9.50	9.33	9.41
5	9.33	9.50	9.41	5	9.00	9.50	9.25
6	9.33	9.00	9.17	6	8.83	8.66	8.75
7	8.83	9.17	9.00	7	8.83	9.00	8.92
8	8.67	8.50	8.58	8	8.67	8.33	8.50
9	9.50	9.50	9.50	9	9.67	9.33	9.50
10	9.33	9.83	9.58	10	9.33	9.83	9.58
11	9.50	9.50	9.50	11	9.33	9.50	9.41
12	9.50	9.83	9.66	12	9.50	9.66	9.58
13	9.66	9.66	9.66	13	9.50	9.83	9.66
14	9.50	10.00	9.75	14	9.50	9.83	9.66
15	8.83	9.83	9.33	15	8.67	9.66	9.16
16	9.83	10.00	9.92	16	9.83	9.66	9.75
17	9.66	9.66	9.66	17	9.66	9.83	9.75
18	9.66	9.33	9.50	18	9.66	9.33	9.50
19	9.66	9.83	9.75	19	9.66	9.83	9.75
20	9.66	9.67	9.66	20	9.66	9.33	9.50
21	9.33	9.83	9.58	21	9.33	9.83	9.58
22	9.00	9.17	9.08	22	9.00	9.17	9.08
Overall average	9.28	9.42	9.35		9.22	9.32	9.27

Table D-7. Discoloration (after 30 and 36 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
30 Months				36 Months			
1	8.00	8.66	8.33	1	7.00	8.33	7.67
2	8.00	8.33	8.17	2	8.00	8.33	8.17
3	8.00	8.00	8.00	3	8.00	8.00	8.00
4	9.66	9.33	9.50	4	9.33	9.33	9.33
5	8.66	9.00	8.83	5	8.33	8.66	8.50
6	9.00	8.33	8.67	6	9.00	7.66	8.33
7	8.66	9.00	8.83	7	8.66	9.00	8.83
8	8.00	8.00	8.00	8	8.00	7.66	7.83
9	9.33	9.66	9.50	9	8.66	9.33	9.00
10	9.00	9.66	9.33	10	8.00	9.66	8.83
11	9.00	9.66	9.33	11	8.66	9.66	9.16
12	9.33	9.33	9.33	12	9.33	9.33	9.33
13	9.66	9.66	9.66	13	9.33	9.33	9.33
14	9.00	10.00	9.50	14	8.66	9.66	9.16
15	9.33	9.33	9.33	15	9.00	9.00	9.00
16	9.33	9.00	9.17	16	9.33	9.00	9.17
17	9.66	9.66	9.66	17	9.33	9.33	9.33
18	9.66	9.30	9.48	18	9.66	9.33	9.50
19	9.30	9.66	9.48	19	9.33	9.66	9.50
20	9.33	8.66	9.00	20	9.33	8.33	8.83
21	9.66	10.00	9.83	21	9.33	9.66	9.50
22	8.00	9.00	8.50	22	8.00	8.66	8.33
Overall average	8.98	9.15	9.06		8.74	8.95	8.85

Table D-8. Discoloration (after 42 and 48 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
42 Months				48 Months			
1	8.00	8.00	8.00	1	7.00	7.66	7.33
2	7.00	8.00	7.50	2	7.00	8.00	7.50
3	1.00	8.33	4.67	3	8.00	8.33	8.17
4	9.66	9.00	9.33	4	9.66	9.00	9.33
5	8.00	8.66	8.33	5	8.00	8.33	8.17
6	9.00	7.66	8.33	6	9.00	7.66	8.33
7	8.66	8.66	8.66	7	8.66	8.66	8.66
8	8.00	7.66	7.83	8	8.00	7.66	7.83
9	8.66	9.00	8.83	9	8.33	8.66	8.50
10	8.00	9.00	8.50	10	8.00	8.66	8.33
11	8.33	8.66	8.50	11	8.33	8.66	8.50
12	9.33	9.00	9.17	12	9.00	9.00	9.00
13	9.33	9.33	9.33	13	9.33	9.00	9.17
14	8.66	9.33	9.00	14	8.66	9.00	8.83
15	9.00	9.00	9.00	15	9.00	9.00	9.00
16	9.33	9.00	9.17	16	9.33	9.00	9.17
17	9.33	9.00	9.17	17	9.33	9.00	9.17
18	9.66	9.33	9.50	18	9.66	9.33	9.50
19	9.00	9.33	9.17	19	8.66	9.33	9.00
20	9.33	8.00	8.67	20	9.00	7.00	8.00
21	9.33	9.33	9.33	21	9.33	9.33	9.33
22	7.00	8.00	7.50	22	6.00	7.00	6.50
Overall average	8.35	8.69	8.52		8.51	8.51	8.51

Table D-9. Chalking (after 6 and 12 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
6 Months				12 Months			
1	10.00	10.00	10.00	1	10.00	9.00	9.50
2	8.00	10.00	9.00	2	7.00	7.50	7.25
3	8.00	9.00	8.50	3	8.00	9.00	8.50
4	10.00	10.00	10.00	4	10.00	9.50	9.75
5	10.00	10.00	10.00	5	8.00	10.00	9.00
6	10.00	9.00	9.50	6	9.50	8.50	9.00
7	10.00	10.00	10.00	7	8.00	8.00	8.00
8	5.00	4.00	4.50	8	7.00	3.00	5.00
9	10.00	10.00	10.00	9	8.00	8.50	8.25
10	9.00	10.00	9.50	10	9.50	9.00	9.25
11	9.00	10.00	9.50	11	9.85	10.00	9.93
12	10.00	10.00	10.00	12	10.00	10.00	10.00
13	10.00	10.00	10.00	13	9.50	8.50	9.00
14	10.00	10.00	10.00	14	8.50	9.00	8.75
15	10.00	9.00	9.50	15	9.00	9.00	9.00
16	10.00	10.00	10.00	16	10.00	10.00	10.00
17	10.00	10.00	10.00	17	8.85	10.00	9.43
18	10.00	10.00	10.00	18	9.50	8.00	8.75
19	10.00	10.00	10.00	19	10.00	8.00	9.00
20	10.00	10.00	10.00	20	9.00	9.50	9.25
21	10.00	10.00	10.00	21	9.00	10.00	9.50
22	10.00	8.00	9.00	22	8.50	7.00	7.75
Overall average	9.50	9.50	9.50		8.94	8.68	8.81

Table D-10. Chalking (after 18 and 24 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
18 Months				24 Months			
1	8.00	8.00	8.00	1	8.00	8.00	8.00
2	8.00	6.50	7.25	2	5.00	6.50	5.75
3	4.00	4.00	4.00	3	4.00	4.00	4.00
4	9.67	9.50	9.58	4	8.67	9.33	9.00
5	8.00	9.00	8.50	5	7.00	8.00	7.50
6	6.00	7.00	6.50	6	6.00	5.00	5.50
7	5.00	4.00	4.50	7	4.00	4.00	4.00
8	4.00	2.00	3.00	8	3.00	2.00	2.50
9	9.00	9.00	9.00	9	8.00	8.00	8.00
10	10.00	8.83	9.42	10	8.00	9.00	8.50
11	9.83	10.00	9.92	11	9.50	9.00	9.25
12	9.83	9.00	9.42	12	8.83	8.00	8.42
13	9.50	8.83	9.17	13	9.00	8.00	8.50
14	10.00	10.00	10.00	14	9.83	9.83	9.83
15	8.00	7.00	7.50	15	7.00	7.00	7.00
16	7.00	9.00	8.00	16	8.83	9.00	8.92
17	7.83	9.00	8.42	17	8.50	9.00	8.75
18	9.83	9.00	9.42	18	9.83	8.50	9.17
19	9.83	10.00	9.92	19	8.83	9.00	8.92
20	9.50	9.50	9.50	20	9.00	8.83	8.92
21	10.00	10.00	10.00	21	8.00	8.83	8.42
22	8.00	8.00	8.00	22	8.00	8.50	8.25
Overall average	8.22	8.05	8.14		7.58	7.61	7.59

Table D-11. Chalking (after 30 and 36 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
30 Months				36 Months			
1	6.00	6.00	6.00	1	6.00	6.00	6.00
2	4.00	2.00	3.00	2	4.00	2.00	3.00
3	2.00	4.00	3.00	3	2.00	4.00	3.00
4	8.00	7.00	7.50	4	8.00	6.00	7.00
5	6.00	7.00	6.50	5	6.00	8.00	7.00
6	6.00	2.00	4.00	6	6.00	2.00	4.00
7	2.00	2.00	2.00	7	2.00	2.00	2.00
8	2.00	2.00	2.00	8	2.00	2.00	2.00
9	6.00	8.00	7.00	9	6.00	8.00	7.00
10	7.00	9.66	8.33	10	9.00	9.66	9.33
11	8.00	6.00	7.00	11	8.00	6.00	7.00
12	9.33	9.00	9.17	12	9.33	9.00	9.17
13	9.00	9.00	9.00	13	9.00	9.00	9.00
14	8.00	10.00	9.00	14	8.00	9.00	8.50
15	4.00	6.00	5.00	15	4.00	6.00	5.00
16	2.00	6.00	4.00	16	2.00	6.00	4.00
17	9.00	9.00	9.00	17	9.00	9.00	9.00
18	8.00	7.00	7.50	18	8.00	7.00	7.50
19	6.00	9.00	7.50	19	6.00	9.00	7.50
20	8.00	9.00	8.50	20	8.00	9.00	8.50
21	6.00	8.00	7.00	21	6.00	8.00	7.00
22	4.00	7.00	5.50	22	4.00	7.00	5.50
Overall average	5.92	6.58	6.25		6.02	6.53	6.27

Table D-12. Chalking (after 42 and 48 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
42 Months				48 Months			
1	6.00	8.00	7.00	1	6.00	8.00	7.00
2	2.00	1.00	1.50	2	2.00	1.00	1.50
3	1.00	4.00	2.50	3	4.00	8.00	6.00
4	9.00	8.00	8.50	4	9.00	6.00	7.50
5	6.00	6.00	6.00	5	8.00	6.00	7.00
6	4.00	2.00	3.00	6	4.00	1.00	2.50
7	2.00	4.00	3.00	7	2.00	2.00	2.00
8	2.00	2.00	2.00	8	2.00	2.00	2.00
9	6.00	9.00	7.50	9	4.00	9.00	6.50
10	9.00	9.66	9.33	10	9.00	9.66	9.33
11	8.00	6.00	7.00	11	6.00	8.00	7.00
12	8.00	9.00	8.50	12	8.00	9.00	8.50
13	9.00	10.00	9.50	13	9.00	8.00	8.50
14	8.00	10.00	9.00	14	10.00	8.00	9.00
15	6.00	6.00	6.00	15	6.00	6.00	6.00
16	2.00	8.00	5.00	16	8.00	10.00	9.00
17	9.00	9.00	9.00	17	8.00	8.00	8.00
18	8.00	8.00	8.00	18	8.00	8.00	8.00
19	6.00	9.00	7.50	19	8.00	9.00	8.50
20	8.00	9.00	8.50	20	8.00	9.00	8.50
21	8.00	8.00	8.00	21	8.00	6.00	7.00
22	2.00	6.00	4.00	22	2.00	8.00	5.00
Overall average	5.86	6.89	6.38		6.32	6.80	6.56

Table D-13. Checking and Alligatoring (after 6 and 12 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
6 Months				12 Months			
1	10.00	10.00	10.00	1	10.00	9.85	9.93
2	10.00	10.00	10.00	2	10.00	10.00	10.00
3	10.00	10.00	10.00	3	10.00	10.00	10.00
4	10.00	10.00	10.00	4	10.00	10.00	10.00
5	10.00	10.00	10.00	5	10.00	10.00	10.00
6	10.00	9.50	9.75	6	10.00	9.00	9.50
7	10.00	10.00	10.00	7	10.00	10.00	10.00
8	9.00	5.00	7.00	8	9.00	4.50	6.75
9	10.00	10.00	10.00	9	9.85	10.00	9.93
10	10.00	10.00	10.00	10	10.00	10.00	10.00
11	10.00	10.00	10.00	11	10.00	10.00	10.00
12	10.00	10.00	10.00	12	10.00	10.00	10.00
13	10.00	10.00	10.00	13	10.00	10.00	10.00
14	10.00	10.00	10.00	14	10.00	10.00	10.00
15	10.00	10.00	10.00	15	10.00	10.00	10.00
16	10.00	10.00	10.00	16	9.85	10.00	9.93
17	10.00	10.00	10.00	17	10.00	10.00	10.00
18	10.00	10.00	10.00	18	10.00	10.00	10.00
19	10.00	10.00	10.00	19	10.00	10.00	10.00
20	10.00	10.00	10.00	20	10.00	10.00	10.00
21	10.00	10.00	10.00	21	10.00	10.00	10.00
22	9.00	10.00	9.50	22	7.00	10.00	8.50
Overall average	9.91	9.75	9.83		9.80	9.70	9.75

Table D-14. Checking and Alligatoring (after 18 and 24 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
18 Months				24 Months			
1	8.00	9.83	8.92	1	6.50	9.33	7.92
2	9.00	9.67	9.33	2	9.00	9.17	9.08
3	9.33	10.00	9.67	3	8.50	10.00	9.25
4	10.00	10.00	10.00	4	10.00	10.00	10.00
5	8.50	10.00	9.25	5	8.50	10.00	9.25
6	8.00	9.15	8.58	6	7.00	9.50	8.25
7	9.83	8.00	8.92	7	9.50	8.00	8.75
8	9.00	4.00	6.50	8	8.00	4.00	6.00
9	8.00	9.17	8.58	9	7.00	9.00	8.00
10	9.83	10.00	9.92	10	10.00	10.00	10.00
11	10.00	10.00	10.00	11	9.00	10.00	9.50
12	10.00	10.00	10.00	12	10.00	10.00	10.00
13	10.00	10.00	10.00	13	10.00	10.00	10.00
14	10.00	10.00	10.00	14	10.00	10.00	10.00
15	10.00	10.00	10.00	15	10.00	10.00	10.00
16	9.66	10.00	9.83	16	9.83	10.00	9.92
17	10.00	10.00	10.00	17	10.00	10.00	10.00
18	10.00	10.00	10.00	18	10.00	9.50	9.75
19	10.00	10.00	10.00	19	9.83	10.00	9.92
20	10.00	10.00	10.00	20	9.50	10.00	9.75
21	10.00	10.00	10.00	21	9.83	10.00	9.92
22	5.00	9.66	7.33	22	4.50	8.83	6.67
Overall average	9.28	9.52	9.40		8.93	9.42	9.18

Table D-15. Checking and Alligatoring (after 30 and 36 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
30 Months				36 Months			
1	9.00	5.00	7.00	1	6.00	4.00	5.00
2	6.00	8.00	7.00	2	6.00	8.00	7.00
3	6.00	9.00	7.50	3	4.00	8.00	6.00
4	10.00	10.00	10.00	4	10.00	10.00	10.00
5	6.00	6.00	6.00	5	4.00	6.00	5.00
6	4.00	9.00	6.50	6	4.00	8.00	6.00
7	8.00	7.00	7.50	7	6.00	6.00	6.00
8	8.00	4.00	6.00	8	6.00	4.00	5.00
9	4.00	8.00	6.00	9	4.00	8.00	6.00
10	10.00	10.00	10.00	10	10.00	10.00	10.00
11	8.00	8.00	8.00	11	8.00	2.00	5.00
12	10.00	10.00	10.00	12	10.00	10.00	10.00
13	10.00	9.66	9.83	13	10.00	9.66	9.83
14	10.00	10.00	10.00	14	10.00	10.00	10.00
15	10.00	9.33	9.67	15	10.00	9.00	9.50
16	10.00	10.00	10.00	16	9.00	9.00	9.00
17	10.00	10.00	10.00	17	10.00	10.00	10.00
18	10.00	10.00	10.00	18	10.00	10.00	10.00
19	10.00	10.00	10.00	19	9.66	10.00	9.83
20	10.00	10.00	10.00	20	10.00	9.00	9.50
21	10.00	10.00	10.00	21	10.00	10.00	10.00
22	5.00	8.00	6.50	22	4.00	6.00	5.00
Overall average	8.36	8.68	8.52		7.76	8.03	7.89

Table D-16. Checking and Alligatoring (after 42 and 48 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
42 Months				48 Months			
1	9.00	4.00	6.50	1	6.00	4.00	5.00
2	6.00	8.00	7.00	2	6.00	8.00	7.00
3	4.00	8.00	6.00	3	3.00	8.00	5.50
4	10.00	10.00	10.00	4	10.00	10.00	10.00
5	4.00	6.00	5.00	5	4.00	4.00	4.00
6	4.00	8.00	6.00	6	4.00	8.00	6.00
7	4.00	6.00	5.00	7	4.00	6.00	5.00
8	6.00	4.00	5.00	8	6.00	4.00	5.00
9	4.00	8.00	6.00	9	4.00	8.00	6.00
10	10.00	10.00	10.00	10	10.00	10.00	10.00
11	8.00	8.00	8.00	11	8.00	8.00	8.00
12	10.00	10.00	10.00	12	10.00	10.00	10.00
13	10.00	9.66	9.83	13	10.00	9.66	9.83
14	10.00	10.00	10.00	14	10.00	10.00	10.00
15	10.00	9.00	9.50	15	10.00	9.00	9.50
16	9.00	9.00	9.00	16	9.33	9.33	9.33
17	10.00	10.00	10.00	17	10.00	10.00	10.00
18	10.00	10.00	10.00	18	10.00	10.00	10.00
19	9.66	10.00	9.83	19	9.66	10.00	9.83
20	10.00	9.00	9.50	20	10.00	9.00	9.50
21	10.00	10.00	10.00	21	10.00	10.00	10.00
22	4.00	5.00	4.50	22	4.00	5.00	4.50
Overall average	7.80	8.26	8.03		7.64	8.18	7.91

Table D-17. Cracking (after 6 and 12 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
6 Months				12 Months			
1	10.00	10.00	10.00	1	7.65	9.50	8.58
2	10.00	10.00	10.00	2	9.50	9.50	9.50
3	9.00	10.00	9.50	3	8.00	10.00	9.00
4	10.00	10.00	10.00	4	10.00	10.00	10.00
5	10.00	10.00	10.00	5	8.00	9.50	8.75
6	10.00	10.00	10.00	6	6.65	9.70	8.18
7	10.00	10.00	10.00	7	7.50	8.00	7.75
8	9.00	10.00	9.50	8	6.00	5.00	5.50
9	8.00	10.00	9.00	9	7.00	10.00	8.50
10	9.50	10.00	9.75	10	9.15	10.00	9.58
11	10.00	10.00	10.00	11	10.00	10.00	10.00
12	10.00	10.00	10.00	12	9.65	10.00	9.83
13	10.00	10.00	10.00	13	10.00	10.00	10.00
14	10.00	10.00	10.00	14	10.00	10.00	10.00
15	10.00	10.00	10.00	15	8.50	10.00	9.25
16	10.00	10.00	10.00	16	9.35	10.00	9.68
17	10.00	10.00	10.00	17	10.00	10.00	10.00
18	10.00	10.00	10.00	18	10.00	9.50	9.75
19	10.00	10.00	10.00	19	10.00	9.50	9.75
20	10.00	10.00	10.00	20	10.00	10.00	10.00
21	10.00	10.00	10.00	21	9.85	10.00	9.93
22	10.00	10.00	10.00	22	8.65	9.50	9.08
Overall average	9.80	10.00	9.90		8.88	9.53	9.21

Table D-18. Cracking (after 18 and 24 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
18 Months				24 Months			
1	4.50	3.50	4.00	1	2.50	4.00	3.25
2	8.50	9.67	9.08	2	5.50	7.50	6.50
3	5.50	9.50	7.50	3	4.50	9.00	6.75
4	10.00	10.00	10.00	4	10.00	10.00	10.00
5	6.00	7.50	6.75	5	5.50	6.50	6.00
6	4.50	9.33	6.92	6	4.50	7.00	5.75
7	7.00	6.50	6.75	7	00	5.50	5.75
8	6.00	4.00	5.00	8	.50	4.00	4.75
9	6.00	9.83	7.92	9	5.50	8.50	7.00
10	9.33	10.00	9.67	10	9.17	9.50	9.33
11	9.83	10.00	9.92	11	8.50	7.50	8.00
12	9.50	10.00	9.75	12	8.00	8.50	8.25
13	10.00	10.00	10.00	13	9.50	9.00	9.25
14	10.00	10.00	10.00	14	10.00	10.00	10.00
15	7.67	10.00	8.83	15	6.50	9.50	8.00
16	9.00	10.00	9.50	16	6.00	9.00	7.50
17	10.00	10.00	10.00	17	10.00	10.00	10.00
18	10.00	10.00	10.00	18	10.00	10.00	10.00
19	9.83	9.50	9.67	19	9.83	9.50	9.67
20	9.67	10.00	9.83	20	7.50	8.50	8.00
21	9.83	10.00	9.92	21	8.50	10.00	9.25
22	6.00	6.50	6.25	22	5.50	5.50	5.50
Overall average	8.12	8.90	8.51		7.20	8.11	7.66

Table D-19. Cracking (after 30 and 36 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
30 Months				36 Months			
1	3.00	4.00	3.50	1	3.00	4.00	3.50
2	5.00	6.00	5.50	2	4.00	6.00	5.00
3	4.00	6.00	5.00	3	4.00	6.00	5.00
4	10.00	10.00	10.00	4	10.00	10.00	10.00
5	4.00	4.00	4.00	5	4.00	4.00	4.00
6	4.00	6.00	5.00	6	4.00	6.00	5.00
7	4.00	5.00	4.50	7	4.00	4.00	4.00
8	4.00	4.00	4.00	8	4.00	4.00	4.00
9	4.00	7.00	5.50	9	4.00	6.00	5.00
10	9.00	9.00	9.00	10	9.00	9.00	9.00
11	9.00	6.00	7.50	11	8.00	6.00	7.00
12	10.00	10.00	10.00	12	10.00	10.00	10.00
13	9.00	9.00	9.00	13	9.00	9.00	9.00
14	10.00	10.00	10.00	14	9.00	10.00	9.50
15	8.00	9.66	8.83	15	4.00	9.00	6.50
16	5.00	9.00	7.00	16	5.00	8.00	6.50
17	10.00	10.00	10.00	17	10.00	10.00	10.00
18	10.00	10.00	10.00	18	10.00	10.00	10.00
19	9.66	10.00	9.83	19	8.00	10.00	9.00
20	6.00	7.00	6.50	20	6.00	7.00	6.50
21	8.00	10.00	9.00	21	6.00	10.00	8.00
22	4.00	5.00	4.50	22	4.00	4.00	4.00
Overall average	6.80	7.58	7.19		6.32	7.36	6.84

Table D-20. Cracking (after 42 and 48 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
42 Months				48 Months			
1	3.00	4.00	3.50	1	3.00	4.00	3.50
2	4.00	6.00	5.00	2	4.00	6.00	5.00
3	4.00	6.00	5.00	3	3.00	6.00	4.50
4	10.00	10.00	10.00	4	10.00	10.00	10.00
5	4.00	4.00	4.00	5	4.00	4.00	4.00
6	2.00	6.00	4.00	6	2.00	6.00	4.00
7	4.00	4.00	4.00	7	4.00	4.00	4.00
8	4.00	4.00	4.00	8	4.00	4.00	4.00
9	4.00	6.00	5.00	9	4.00	6.00	5.00
10	9.00	9.00	9.00	10	6.00	9.00	7.50
11	8.00	6.00	7.00	11	7.00	6.00	6.50
12	7.00	10.00	8.50	12	6.00	10.00	8.00
13	9.00	9.00	9.00	13	9.00	9.00	9.00
14	9.00	10.00	9.50	14	9.00	10.00	9.50
15	5.00	9.00	7.00	15	4.00	9.00	6.50
16	5.00	8.00	6.50	16	5.00	8.00	6.50
17	10.00	10.00	10.00	17	10.00	10.00	10.00
18	9.33	10.00	9.67	18	9.33	10.00	9.67
19	8.00	10.00	9.00	19	8.00	10.00	9.00
20	6.00	6.00	6.00	20	5.00	6.00	5.50
21	6.00	10.00	8.00	21	4.00	10.00	7.00
22	4.00	4.00	4.00	22	4.00	4.00	4.00
Overall average	6.11	7.32	6.71		5.65	7.32	6.48

Table D-21. Flaking, Peeling, and Scaling (after 6 and 12 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
6 Months				12 Months			
1	10.00	10.00	10.00	1	10.00	10.00	10.00
2	10.00	10.00	10.00	2	9.70	10.00	9.85
3	10.00	10.00	10.00	3	9.85	10.00	9.93
4	10.00	10.00	10.00	4	10.00	10.00	10.00
5	10.00	10.00	10.00	5	9.85	10.00	9.93
6	10.00	10.00	10.00	6	10.00	10.00	10.00
7	10.00	10.00	10.00	7	9.85	9.85	9.85
8	10.00	10.00	10.00	8	9.85	9.70	9.78
9	10.00	10.00	10.00	9	9.65	10.00	9.83
10	10.00	10.00	10.00	10	9.85	10.00	9.93
11	10.00	10.00	10.00	11	10.00	10.00	10.00
12	10.00	10.00	10.00	12	10.00	10.00	10.00
13	10.00	10.00	10.00	13	10.00	10.00	10.00
14	10.00	10.00	10.00	14	10.00	10.00	10.00
15	9.00	10.00	9.50	15	9.00	10.00	9.50
16	10.00	10.00	10.00	16	10.00	10.00	10.00
17	10.00	10.00	10.00	17	10.00	10.00	10.00
18	10.00	10.00	10.00	18	10.00	10.00	10.00
19	10.00	10.00	10.00	19	10.00	10.00	10.00
20	10.00	10.00	10.00	20	10.00	10.00	10.00
21	10.00	10.00	10.00	21	10.00	10.00	10.00
22	10.00	10.00	10.00	22	9.85	9.70	9.78
Overall average	9.95	10.00	9.98		9.88	9.97	9.93

Table D-22. Flaking, Peeling, and Scaling (after 18 and 24 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
18 Months				24 Months			
1	9.00	8.67	8.83	1	7.50	8.67	8.08
2	9.50	9.83	9.66	2	9.50	9.83	9.66
3	9.50	10.00	9.75	3	9.48	10.00	9.74
4	10.00	10.00	10.00	4	10.00	10.00	10.00
5	9.50	10.00	9.75	5	9.50	10.00	9.75
6	10.00	10.00	10.00	6	10.00	10.00	10.00
7	10.00	10.00	10.00	7	10.00	10.00	10.00
8	9.83	9.83	9.83	8	10.00	10.00	10.00
9	10.00	10.00	10.00	9	10.00	10.00	10.00
10	9.83	10.00	9.92	10	10.00	10.00	10.00
11	10.00	10.00	10.00	11	10.00	10.00	10.00
12	10.00	10.00	10.00	12	10.00	10.00	10.00
13	10.00	10.00	10.00	13	10.00	10.00	10.00
14	10.00	10.00	10.00	14	10.00	10.00	10.00
15	8.00	10.00	9.00	15	8.00	10.00	9.00
16	9.83	10.00	9.92	16	9.66	10.00	9.83
17	10.00	10.00	10.00	17	10.00	10.00	10.00
18	10.00	10.00	10.00	18	10.00	10.00	10.00
19	10.00	10.00	10.00	19	10.00	10.00	10.00
20	10.00	10.00	10.00	20	10.00	10.00	10.00
21	10.00	10.00	10.00	21	10.00	10.00	10.00
22	9.50	9.33	9.42	22	9.50	9.33	9.42
Overall average	9.75	9.89	9.82		9.69	9.90	9.79

Table D-23. Flaking, Peeling, and Scaling (after 30 and 36 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
30 Months				36 Months			
1	2.00	6.00	4.00	1	2.00	4.00	3.00
2	9.00	10.00	9.50	2	8.00	10.00	9.00
3	5.00	10.00	7.50	3	4.00	10.00	7.00
4	10.00	10.00	10.00	4	10.00	10.00	10.00
5	8.00	10.00	9.00	5	6.00	10.00	8.00
6	10.00	10.00	10.00	6	6.00	10.00	8.00
7	9.00	10.00	9.50	7	9.00	10.00	9.50
8	10.00	9.66	9.83	8	9.00	9.66	9.33
9	8.00	10.00	9.00	9	8.00	10.00	9.00
10	10.00	10.00	10.00	10	10.00	10.00	10.00
11	10.00	10.00	10.00	11	10.00	10.00	10.00
12	10.00	10.00	10.00	12	10.00	10.00	10.00
13	10.00	10.00	10.00	13	10.00	10.00	10.00
14	10.00	10.00	10.00	14	10.00	10.00	10.00
15	10.00	10.00	10.00	15	9.00	10.00	9.50
16	9.66	10.00	9.83	16	9.66	10.00	9.83
17	10.00	10.00	10.00	17	10.00	10.00	10.00
18	10.00	10.00	10.00	18	10.00	10.00	10.00
19	9.66	10.00	9.83	19	9.66	10.00	9.83
20	10.00	10.00	10.00	20	10.00	10.00	10.00
21	10.00	10.00	10.00	21	10.00	10.00	10.00
22	7.00	7.00	7.00	22	6.00	6.00	6.00
Overall average	8.97	9.67	9.32		8.47	9.53	9.00

Table D-24. Flaking, Peeling, and Scaling (after 42 and 48 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
42 Months				48 Months			
1	2.00	4.00	3.00	1	2.00	4.00	3.00
2	8.00	10.00	9.00	2	8.00	10.00	9.00
3	4.00	10.00	7.00	3	3.00	10.00	6.50
4	10.00	10.00	10.00	4	10.00	10.00	10.00
5	6.00	8.00	7.00	5	6.00	8.00	7.00
6	4.00	10.00	7.00	6	4.00	9.33	6.67
7	8.00	10.00	9.00	7	8.00	10.00	9.00
8	9.00	9.66	9.33	8	9.00	9.66	9.33
9	8.00	10.00	9.00	9	8.00	10.00	9.00
10	10.00	10.00	10.00	10	10.00	10.00	10.00
11	9.00	10.00	9.50	11	4.00	10.00	7.00
12	9.00	10.00	9.50	12	9.00	10.00	9.50
13	10.00	10.00	10.00	13	10.00	10.00	10.00
14	10.00	10.00	10.00	14	10.00	10.00	10.00
15	9.00	10.00	9.50	15	9.00	10.00	9.50
16	9.66	10.00	9.83	16	9.66	10.00	9.83
17	10.00	10.00	10.00	17	10.00	10.00	10.00
18	10.00	10.00	10.00	18	10.00	10.00	10.00
19	9.66	10.00	9.83	19	9.66	10.00	9.83
20	10.00	10.00	10.00	20	10.00	10.00	10.00
21	10.00	10.00	10.00	21	10.00	10.00	10.00
22	6.00	4.00	5.00	22	4.00	4.00	4.00
Overall average	8.24	9.35	8.80		7.88	9.32	8.60

Table D-25. Erosion (after 6 and 12 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
6 Months				12 Months			
1	10.00	9.50	9.75	1	9.65	9.35	9.50
2	10.00	9.00	9.50	2	9.00	9.00	9.00
3	9.50	10.00	9.75	3	9.15	9.70	9.43
4	10.00	10.00	10.00	4	9.50	9.70	9.60
5	10.00	10.00	10.00	5	9.35	9.30	9.33
6	10.00	10.00	10.00	6	9.50	9.70	9.60
7	10.00	10.00	10.00	7	9.50	9.70	9.60
8	9.50	10.00	9.75	8	9.35	9.70	9.53
9	10.00	9.85	9.93	9	9.70	9.70	9.70
10	9.85	9.85	9.85	10	9.50	9.70	9.60
11	10.00	9.85	9.93	11	9.70	9.15	9.43
12	10.00	10.00	10.00	12	9.70	9.85	9.78
13	9.50	9.85	9.68	13	9.35	9.85	9.60
14	10.00	10.00	10.00	14	9.70	10.00	9.85
15	10.00	10.00	10.00	15	9.85	9.65	9.75
16	10.00	10.00	10.00	16	9.70	10.00	9.85
17	10.00	10.00	10.00	17	9.70	9.85	9.78
18	10.00	10.00	10.00	18	9.70	9.85	9.78
19	10.00	10.00	10.00	19	9.85	9.85	9.85
20	10.00	10.00	10.00	20	9.70	9.85	9.78
21	9.50	9.70	9.60	21	9.50	9.70	9.60
22	10.00	8.50	9.25	22	9.00	9.00	9.00
Overall average	9.90	9.82	9.86		9.53	9.64	9.59

Table D-26. Erosion (after 18 and 24 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
18 Months				24 Months			
1	9.33	9.17	9.25	1	8.50	9.17	8.83
2	9.00	8.83	8.92	2	8.83	8.83	8.83
3	9.00	8.83	8.92	3	8.83	8.67	8.75
4	9.50	9.66	9.58	4	9.50	9.66	9.58
5	9.83	9.33	9.58	5	9.83	9.33	9.58
6	8.83	9.66	9.25	6	8.50	9.17	8.83
7	9.50	9.66	9.58	7	9.50	9.50	9.50
8	9.50	9.50	9.50	8	9.00	9.00	9.00
9	9.50	9.66	9.58	9	9.17	9.66	9.41
10	9.50	9.66	9.58	10	9.50	9.66	9.58
11	9.66	9.50	9.58	11	9.83	9.50	9.66
12	9.66	9.66	9.66	12	9.83	9.66	9.75
13	9.33	9.83	9.58	13	9.50	9.66	9.58
14	9.66	10.00	9.83	14	9.66	9.66	9.66
15	8.83	9.50	9.16	15	8.67	9.50	9.08
16	9.66	10.00	9.83	16	9.66	9.66	9.66
17	9.66	9.66	9.66	17	9.83	9.83	9.83
18	9.83	9.83	9.83	18	9.83	10.00	9.92
19	9.66	9.66	9.66	19	9.66	9.66	9.66
20	9.66	9.83	9.75	20	9.50	9.83	9.66
21	9.16	9.66	9.41	21	9.16	9.66	9.41
22	9.00	8.67	8.83	22	9.00	8.67	8.83
Overall average	9.42	9.53	9.48		9.33	9.45	9.39

Table D-27. Erosion (after 30 and 36 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
30 Months				36 Months			
1	9.33	9.00	9.17	1	6.00	6.00	6.00
2	8.00	8.00	8.00	2	8.00	8.00	8.00
3	8.00	9.00	8.50	3	6.00	9.00	7.50
4	9.66	9.66	9.66	4	9.66	9.66	9.66
5	9.00	9.00	9.00	5	8.00	8.00	8.00
6	9.00	8.00	8.50	6	8.00	8.00	8.00
7	9.00	9.00	9.00	7	9.00	9.00	9.00
8	9.00	8.00	8.50	8	9.00	8.00	8.50
9	9.33	9.33	9.33	9	8.00	9.33	8.67
10	9.33	9.66	9.50	10	9.00	9.66	9.33
11	9.66	9.00	9.33	11	8.00	9.00	8.50
12	9.33	9.33	9.33	12	9.33	9.33	9.33
13	10.00	9.66	9.83	13	9.00	9.33	9.17
14	8.00	9.66	8.83	14	8.00	9.66	8.83
15	9.33	9.33	9.33	15	9.33	9.00	9.17
16	9.66	9.33	9.50	16	9.66	9.33	9.50
17	9.66	9.66	9.66	17	9.33	9.66	9.50
18	9.66	10.00	9.83	18	9.66	9.66	9.66
19	9.33	9.66	9.50	19	8.00	9.66	8.83
20	9.33	8.00	8.67	20	9.00	8.00	8.50
21	9.33	9.66	9.50	21	8.00	9.66	8.83
22	8.00	8.00	8.00	22	6.00	6.00	6.00
Overall average	9.13	9.09	9.11		8.36	8.77	8.57

Table D-28. Erosion (after 42 and 48 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
42 Months				48 Months			
1	9.33	6.00	7.67	1	6.00	6.00	6.00
2	8.00	8.00	8.00	2	8.00	8.00	8.00
3	6.00	9.00	7.50	3	5.00	9.00	7.00
4	9.66	9.66	9.66	4	9.66	9.33	9.50
5	7.00	7.00	7.00	5	7.00	6.00	6.50
6	8.00	8.00	8.00	6	8.00	8.00	8.00
7	9.00	8.00	8.50	7	8.66	8.00	8.33
8	7.00	8.00	7.50	8	6.00	8.00	7.00
9	8.00	9.33	8.67	9	7.00	9.33	8.17
10	9.00	9.33	9.17	10	9.00	9.33	9.17
11	8.00	8.00	8.00	11	8.00	8.00	8.00
12	9.00	9.00	9.00	12	9.00	9.00	9.00
13	9.33	9.00	9.17	13	9.33	9.00	9.17
14	8.00	9.66	8.83	14	8.00	9.33	8.67
15	9.33	9.00	9.17	15	9.00	9.00	9.00
16	9.66	9.33	9.50	16	9.66	9.33	9.50
17	9.33	9.33	9.33	17	9.33	9.33	9.33
18	9.66	9.66	9.66	18	9.66	9.66	9.66
19	8.00	9.33	8.67	19	8.00	9.33	8.67
20	8.00	7.00	7.50	20	8.00	7.00	7.50
21	8.00	9.33	8.67	21	8.00	9.33	8.67
22	6.00	6.00	6.00	22	6.00	4.00	5.00
Overall average	8.33	8.50	8.42		8.01	8.33	8.17

Table D-29. Blistering (after 6 and 12 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
6 Months				12 Months			
1	10.00	10.00	10.00	1	10.00	10.00	10.00
2	10.00	10.00	10.00	2	10.00	10.00	10.00
3	10.00	10.00	10.00	3	10.00	10.00	10.00
4	10.00	10.00	10.00	4	10.00	10.00	10.00
5	10.00	10.00	10.00	5	10.00	10.00	10.00
6	10.00	10.00	10.00	6	10.00	10.00	10.00
7	10.00	10.00	10.00	7	10.00	10.00	10.00
8	10.00	10.00	10.00	8	10.00	10.00	10.00
9	10.00	10.00	10.00	9	10.00	10.00	10.00
10	10.00	10.00	10.00	10	10.00	10.00	10.00
11	10.00	10.00	10.00	11	10.00	10.00	10.00
12	10.00	10.00	10.00	12	10.00	10.00	10.00
13	10.00	10.00	10.00	13	10.00	10.00	10.00
14	10.00	10.00	10.00	14	10.00	10.00	10.00
15	10.00	10.00	10.00	15	10.00	10.00	10.00
16	10.00	10.00	10.00	16	10.00	10.00	10.00
17	10.00	10.00	10.00	17	10.00	10.00	10.00
18	10.00	10.00	10.00	18	10.00	10.00	10.00
19	10.00	10.00	10.00	19	10.00	10.00	10.00
20	10.00	10.00	10.00	20	10.00	10.00	10.00
21	10.00	10.00	10.00	21	10.00	10.00	10.00
22	10.00	10.00	10.00	22	10.00	10.00	10.00
Overall average	10.00	10.00	10.00		10.00	10.00	10.00

Table D-30. Blistering (after 18 and 24 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
18 Months				24 Months			
1	10.00	10.00	10.00	1	10.00	10.00	10.00
2	10.00	10.00	10.00	2	10.00	10.00	10.00
3	10.00	10.00	10.00	3	10.00	10.00	10.00
4	10.00	10.00	10.00	4	10.00	10.00	10.00
5	10.00	10.00	10.00	5	10.00	10.00	10.00
6	10.00	10.00	10.00	6	10.00	10.00	10.00
7	10.00	10.00	10.00	7	10.00	10.00	10.00
8	10.00	10.00	10.00	8	10.00	10.00	10.00
9	10.00	10.00	10.00	9	10.00	10.00	10.00
10	10.00	10.00	10.00	10	10.00	10.00	10.00
11	10.00	10.00	10.00	11	10.00	10.00	10.00
12	10.00	10.00	10.00	12	10.00	10.00	10.00
13	10.00	10.00	10.00	13	10.00	10.00	10.00
14	10.00	10.00	10.00	14	10.00	10.00	10.00
15	10.00	10.00	10.00	15	10.00	10.00	10.00
16	10.00	10.00	10.00	16	10.00	10.00	10.00
17	10.00	10.00	10.00	17	10.00	10.00	10.00
18	10.00	10.00	10.00	18	10.00	10.00	10.00
19	10.00	10.00	10.00	19	10.00	10.00	10.00
20	10.00	10.00	10.00	20	10.00	10.00	10.00
21	10.00	10.00	10.00	21	10.00	10.00	10.00
22	10.00	10.00	10.00	22	10.00	10.00	10.00
Overall average	10.00	10.00	10.00		10.00	10.00	10.00

Table D-31. Blistering (after 30 and 36 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
30 Months				36 Months			
1	10.00	10.00	10.00	1	10.00	10.00	10.00
2	10.00	10.00	10.00	2	10.00	10.00	10.00
3	10.00	10.00	10.00	3	10.00	10.00	10.00
4	10.00	10.00	10.00	4	10.00	10.00	10.00
5	10.00	10.00	10.00	5	10.00	10.00	10.00
6	10.00	10.00	10.00	6	10.00	10.00	10.00
7	10.00	10.00	10.00	7	10.00	10.00	10.00
8	10.00	10.00	10.00	8	10.00	10.00	10.00
9	10.00	10.00	10.00	9	10.00	10.00	10.00
10	10.00	10.00	10.00	10	10.00	10.00	10.00
11	10.00	10.00	10.00	11	10.00	10.00	10.00
12	10.00	10.00	10.00	12	10.00	10.00	10.00
13	10.00	10.00	10.00	13	10.00	10.00	10.00
14	10.00	10.00	10.00	14	10.00	10.00	10.00
15	10.00	10.00	10.00	15	10.00	10.00	10.00
16	10.00	10.00	10.00	16	10.00	10.00	10.00
17	10.00	10.00	10.00	17	10.00	10.00	10.00
18	10.00	10.00	10.00	18	10.00	10.00	10.00
19	10.00	10.00	10.00	19	10.00	10.00	10.00
20	10.00	10.00	10.00	20	10.00	10.00	10.00
21	10.00	10.00	10.00	21	10.00	10.00	10.00
22	10.00	10.00	10.00	22	10.00	10.00	10.00
Overall average	10.00	10.00	10.00		10.00	10.00	10.00

Table D-32. Blistering (after 42 and 48 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
42 Months				48 Months			
1	10.00	10.00	10.00	1	10.00	10.00	10.00
2	10.00	10.00	10.00	2	10.00	10.00	10.00
3	10.00	10.00	10.00	3	10.00	10.00	10.00
4	10.00	10.00	10.00	4	10.00	10.00	10.00
5	10.00	10.00	10.00	5	10.00	10.00	10.00
6	10.00	10.00	10.00	6	10.00	10.00	10.00
7	10.00	10.00	10.00	7	10.00	10.00	10.00
8	10.00	10.00	10.00	8	10.00	10.00	10.00
9	10.00	10.00	10.00	9	10.00	10.00	10.00
10	10.00	10.00	10.00	10	10.00	10.00	10.00
11	10.00	10.00	10.00	11	10.00	10.00	10.00
12	10.00	10.00	10.00	12	10.00	10.00	10.00
13	10.00	10.00	10.00	13	10.00	10.00	10.00
14	10.00	10.00	10.00	14	10.00	10.00	10.00
15	10.00	10.00	10.00	15	10.00	10.00	10.00
16	10.00	10.00	10.00	16	10.00	10.00	10.00
17	10.00	10.00	10.00	17	10.00	10.00	10.00
18	10.00	10.00	10.00	18	10.00	10.00	10.00
19	10.00	10.00	10.00	19	10.00	10.00	10.00
20	10.00	10.00	10.00	20	10.00	10.00	10.00
21	10.00	10.00	10.00	21	10.00	10.00	10.00
22	10.00	10.00	10.00	22	10.00	10.00	10.00
Overall average	10.00	10.00	10.00		10.00	10.00	10.00

Table D-33. Mildew (after 6 and 12 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
6 Months				12 Months			
1	9.50	8.00	8.75	1	8.00	9.00	8.50
2	9.50	8.50	9.00	2	7.50	8.50	8.00
3	8.00	9.00	8.50	3	8.00	8.65	8.33
4	10.00	10.00	10.00	4	9.85	9.70	9.78
5	9.50	7.50	8.50	5	9.00	9.50	9.25
6	10.00	9.00	9.50	6	9.50	9.00	9.25
7	8.50	8.00	8.25	7	8.35	8.00	8.18
8	10.00	10.00	10.00	8	9.35	8.00	8.68
9	9.50	8.50	9.00	9	9.00	9.50	9.25
10	10.00	10.00	10.00	10	9.85	9.85	9.85
11	9.50	7.50	8.50	11	9.85	9.00	9.43
12	9.50	10.00	9.75	12	9.50	9.85	9.68
13	10.00	10.00	10.00	13	7.85	9.70	8.78
14	10.00	10.00	10.00	14	9.70	9.85	9.78
15	10.00	9.85	9.93	15	8.85	9.35	9.10
16	10.00	10.00	10.00	16	10.00	10.00	10.00
17	10.00	10.00	10.00	17	9.70	10.00	9.85
18	10.00	10.00	10.00	18	10.00	10.00	10.00
19	10.00	10.00	10.00	19	9.85	9.85	9.85
20	10.00	10.00	10.00	20	9.30	9.85	9.58
21	10.00	10.00	10.00	21	9.50	9.85	9.68
22	5.50	8.00	6.75	22	8.50	9.35	8.93
Overall average	9.50	9.27	9.38		9.14	9.38	9.26

Table D-34. Mildew (after 18 and 24 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
18 Months				24 Months			
1	9.00	9.32	9.16	1	9.35	9.50	9.42
2	8.17	8.33	8.25	2	9.17	8.50	8.83
3	8.17	8.00	8.08	3	8.50	7.17	7.83
4	9.66	9.83	9.75	4	10.00	9.83	9.92
5	9.33	9.83	9.58	5	9.83	9.83	9.83
6	10.00	9.17	9.58	6	9.33	8.00	8.67
7	9.00	9.00	9.00	7	9.50	9.17	9.33
8	9.17	7.50	8.33	8	9.33	7.50	8.42
9	9.66	9.66	9.66	9	10.00	9.33	9.67
10	9.66	10.00	9.83	10	9.83	9.83	9.83
11	9.50	9.83	9.66	11	9.33	9.33	9.33
12	9.66	10.00	9.83	12	10.00	9.66	9.83
13	9.00	9.83	9.42	13	9.50	9.66	9.58
14	9.66	9.83	9.75	14	9.83	10.00	9.92
15	9.50	9.66	9.58	15	9.66	9.33	9.50
16	9.83	10.00	9.92	16	10.00	9.83	9.92
17	9.50	9.66	9.58	17	10.00	9.83	9.92
18	10.00	9.83	9.92	18	10.00	9.83	9.92
19	9.66	9.83	9.75	19	9.83	9.66	9.75
20	9.67	9.83	9.75	20	9.83	9.33	9.58
21	9.50	9.83	9.66	21	9.66	9.66	9.66
22	9.83	9.50	9.66	22	9.33	9.33	9.33
Overall average	9.41	9.47	9.44		9.63	9.28	9.45

Table D-35. Mildew (after 30 and 36 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
30 Months				36 Months			
1	10.00	10.00	10.00	1	10.00	10.00	10.00
2	10.00	10.00	10.00	2	10.00	10.00	10.00
3	10.00	10.00	10.00	3	10.00	10.00	10.00
4	10.00	10.00	10.00	4	10.00	10.00	10.00
5	10.00	10.00	10.00	5	10.00	10.00	10.00
6	10.00	10.00	10.00	6	10.00	10.00	10.00
7	10.00	10.00	10.00	7	10.00	10.00	10.00
8	10.00	10.00	10.00	8	10.00	10.00	10.00
9	10.00	10.00	10.00	9	10.00	10.00	10.00
10	10.00	10.00	10.00	10	10.00	10.00	10.00
11	10.00	10.00	10.00	11	10.00	10.00	10.00
12	10.00	10.00	10.00	12	10.00	10.00	10.00
13	10.00	10.00	10.00	13	10.00	10.00	10.00
14	10.00	10.00	10.00	14	10.00	10.00	10.00
15	10.00	10.00	10.00	15	10.00	10.00	10.00
16	10.00	10.00	10.00	16	10.00	10.00	10.00
17	10.00	10.00	10.00	17	10.00	10.00	10.00
18	10.00	10.00	10.00	18	10.00	10.00	10.00
19	10.00	10.00	10.00	19	10.00	10.00	10.00
20	10.00	10.00	10.00	20	10.00	10.00	10.00
21	10.00	10.00	10.00	21	10.00	10.00	10.00
22	10.00	10.00	10.00	22	10.00	10.00	10.00
Overall average	10.00	10.00	10.00		10.00	10.00	10.00

*Microscopic examination of mildew-like stain on the plywood panels revealed that there were no mildew causing organisms on the coatings. Hence, the ratings were corrected to 10 accordingly.

Table D-36. Mildew (after 42 and 48 months)

System Number	Smooth Surface	Rough Surface	Average	System Number	Smooth Surface	Rough Surface	Average
42 Months				48 Months			
1	10.00	10.00	10.00	1	10.00	10.00	10.00
2	10.00	10.00	10.00	2	10.00	10.00	10.00
3	10.00	10.00	10.00	3	10.00	10.00	10.00
4	10.00	10.00	10.00	4	10.00	10.00	10.00
5	10.00	10.00	10.00	5	10.00	10.00	10.00
6	10.00	10.00	10.00	6	10.00	10.00	10.00
7	10.00	10.00	10.00	7	10.00	10.00	10.00
8	10.00	10.00	10.00	8	10.00	10.00	10.00
9	10.00	10.00	10.00	9	10.00	10.00	10.00
10	10.00	10.00	10.00	10	10.00	10.00	10.00
11	10.00	10.00	10.00	11	10.00	10.00	10.00
12	10.00	10.00	10.00	12	10.00	10.00	10.00
13	10.00	10.00	10.00	13	10.00	10.00	10.00
14	10.00	10.00	10.00	14	10.00	10.00	10.00
15	10.00	10.00	10.00	15	10.00	10.00	10.00
16	10.00	10.00	10.00	16	10.00	10.00	10.00
17	10.00	10.00	10.00	17	10.00	10.00	10.00
18	10.00	10.00	10.00	18	10.00	10.00	10.00
19	10.00	10.00	10.00	19	10.00	10.00	10.00
20	10.00	10.00	10.00	20	10.00	10.00	10.00
21	10.00	10.00	10.00	21	10.00	10.00	10.00
22	10.00	10.00	10.00	22	10.00	10.00	10.00
Overall average	10.00	10.00	10.00		10.00	10.00	10.00

Appendix E

PERFORMANCE RANKINGS AND SCORES FOR COATING SYSTEMS

Table E-1. Performance Ranking and Scores and Coating Systems After 4 Years at the Kwajalein Test Site (General Protection)

Rank	System Number	Score	Primer		Topcoat	
			Specification	Type	Specification	Type
1	18	9.55	Sinclair AP8-11	Latex	Sinclair 1300	Latex
2	4	9.50	SUNCO	Latex	SUNCO	Latex
3	13	9.33	TT-P-001984	Latex	UCAR 19-93-A	Latex
3	17	9.33	Sinclair AP8-11	Latex	Sinclair 4400	Latex
3	21	9.33	TT-P-001984	Latex	Standard Brands F6674-5	Latex
6	14	9.17	Sinclair AP8-11	Latex	Sinclair 4800	Latex
6	16	9.17	TT-P-001984	Latex	Standard Brands F6674-2	Latex
8	15	9.00	TT-P-001984	Latex	Standard Brands F6674-1	Latex
8	19	9.00	TT-P-001984	Latex	Standard Brands F6674-3	Latex
10	10	8.83	TT-P-001984	Latex	UCAR 19-92-A	Latex
10	12	8.83	TT-P-001984	Latex	UCAR 19-92-C	Latex
12	9	8.67	TT-P-001984	Latex	Ameritone W9900	Latex
12	11	8.67	TT-P-001984	Latex	UCAR 19-92-B	Latex
12	20	8.67	TT-P-001984	Latex	Standard Brands F6674-4	Latex
15	7	8.50	TT-P-001984	Latex	TT-P-1510	Latex
16	2	8.33	MIL-P-28582	Alkyd	TT-P-19	Latex
17	5	8.16	TT-P-001984	Latex	TT-E-529	Alkyd
17	6	8.16	TT-P-001984	Latex	TT-P-19	Latex
19	8	8.00	TT-P-001984	Latex	TT-P-96	Latex
20	3	7.83	MIL-P-28582	Alkyd	TT-P-1510	Latex
20	22	7.83	Amoco WS-549	Alkyd[a]	Amoco WS-549	Alkyd[a]
22	1	6.83	MIL-P-28582	Alkyd	TT-E-529	Alkyd

[a]Water-reducible alkyd.

Table E-2. Performance Ranking Scores and Coating Systems Exposed for 3 Years at Kwajalein Test Site (General Protection)

Rank	System Number	Score	Primer		Topcoat	
			Specification	Type	Specification	Type
1	18	9.50	SINCLAIR AP8-11	Latex	SINCLAIR 1300	Latex
2	17	9.33	SINCLAIR AP811	Latex	SINCLAIR 4400	Latex
2	12	9.33	TT-P-001984	Latex	UCAR 19-92-C	Latex
2	13	9.33	TT-P-001984	Latex	UCAR 19-93-A	Latex
2	21	9.33	TT-P-001984	Latex	Standard Brands F6674-5	Latex
2	4	9.33	SUNCO	Latex	SUNCO	Latex
7	10	9.17	TT-P-001984	Latex	UCAR 19-92-A	Latex
7	19	9.17	TT-P-001984	Latex	Standard Brands F6674-3	Latex
7	5	9.17	TT-P-001984	Latex	TT-E-529	Alkyd
10	14	9.16	SINCLAIR AP8-11	Latex	SINCLAIR 4800	Latex
10	11	9.16	TT-P-001984	Latex	UCAR 19-92-B	Latex
12	15	9.00	TT-P-001984	Latex	Standard Brands F6674-1	Latex
13	16	8.83	TT-P-001984	Latex	Standard Brands F6674-2	Latex
13	9	8.83	TT-P-001984	Latex	Ameritone W9900	Latex
15	20	8.66	TT-P-001984	Latex	Standard Brands F6674-4	Latex
15	7	8.66	TT-P-001984	Latex	TT-P-1510	Latex
17	6	8.33	TT-P-001984	Latex	TT-P-19	Latex
17	2	8.33	TT-P-28582	Alkyd	TT-P-19	Latex
19	22	8.17	AMOCO WS-549	Alkyd[a]	AMOCO WS-549	Alkyd
10	3	8.16	MIL-P-28582	Alkyd	TT-P-1510	Latex
21	8	8.00	TT-P-001984	Latex	TT-P-96	Latex
22	1	7.00	MIL-P-28582	Alkyd	TT-E-529	Alkyd

[a]Water-reducible alkyd.

Table E-3. Performance Ranking and Scores for Coating Systems After 4 Years at the Kwajalein Test Site (Discoloration)

Rank	System Number	Score	Primer		Topcoat	
			Specification	Type	Specification	Type
1	18	9.50	Sinclair AP8-11	Latex	Sinclair 1300	Latex
2	4	9.33	SUNCO	Latex	SUNCO	Latex
2	21	9.33	TT-P-001984	Latex	Standard Brands F6674-5	Latex
4	13	9.17	TT-P-001984	Latex	UCAR 19-93-A	Latex
4	16	9.17	TT-P-001984	Latex	Standard Brands F6674-2	Latex
4	17	9.17	Sinclair AP8-11	Latex	Sinclair 4400	Latex
7	12	9.00	TT-P-001984	Latex	UCAR 19-92-C	Latex
7	15	9.00	TT-P-001984	Latex	Standard Brands F6674-1	Latex
7	19	9.00	TT-P-001984	Latex	Standard Brands F6674-3	Latex
10	14	8.83	Sinclair AP8-11	Latex	Sinclair 4800	Latex
11	7	8.66	TT-P-001984	Latex	TT-P-1510	Latex
12	9	8.50	TT-P-001984	Latex	Ameritone W9900	Latex
12	11	8.50	TT-P-001984	Latex	UCAR 19-92-B	Latex
14	6	8.33	TT-P-001984	Latex	TT-P-19	Latex
14	10	8.33	TT-P-001984	Latex	UCAR 19-92-A	Latex
16	3	8.17	MIL-P-28582	Alkyd	TT-P-1510	Latex
16	5	8.17	TT-P-001984	Latex	TT-E-529	Alkyd
18	20	8.00	TT-P-001984	Latex	Standard Brands F6674-4	Latex
19	8	7.83	TT-P-001984	Latex	TT-P-96	Latex
20	2	7.50	MIL-P-28582	Alkyd	TT-P-19	Latex
21	1	7.33	MIL-P-28582	Alkyd	TT-E-529	Alkyd
22	22	6.50	Amoco WS-549	Alkyd[a]	Amoco WS-549	Alkyd[a]

[a]Water-reducible alkyd.

Table E-4. Performance Ranking and Scores for Coating Systems After 3 Years at the Kwajalein Test Site (Discoloration)

Rank	System Number	Score	Primer		Topcoat	
			Specification	Type	Specification	Type
1	18	9.50	Sinclair AP8-11	Latex	Sinclair 1300	Latex
1	19	9.50	TT-P-001984	Latex	Standard Brands F6674-3	Latex
1	21	9.50	TT-P-001984	Latex	Standard Brands F6674-5	Latex
4	17	9.33	Sinclair AP8-11	Latex	Sinclair 4400	Latex
4	4	9.33	SUNCO	Latex	SUNCO	Latex
4	12	9.33	TT-P-001984	Latex	UCAR 19-92-C	Latex
4	13	9.33	TT-P-001984	Latex	UCAR 19-93-A	Latex
8	16	9.17	TT-P-001984	Latex	Standard Brands F6674-2	Latex
9	14	9.16	Sinclair AP8-11	Latex	Sinclair 4800	Latex
9	11	9.16	TT-P-001984	Latex	UCAR 19-92-B	Latex
11	15	9.00	TT-P-001984	Latex	Standard Brands F6674-1	Latex
11	9	9.00	TT-P-001984	Latex	Ameritone W9900	Latex
13	20	8.83	TT-P-001984	Latex	Standard Brands F6674-4	Latex
13	10	8.83	TT-P-001984	Latex	UCAR 19-92-A	Latex
13	7	8.83	TT-P-001984	Latex	TT-P-1510	Latex
16	5	8.50	TT-P-001984	Latex	TT-E-529	Alkyd
17	22	8.33	Amoco WS-549	Alkyd[a]	Amoco WS-549	Alkyd[a]
17	6	8.33	TT-P-001984	Latex	TT-P-19	Latex
19	2	8.17	TT-P-28582	Alkyd	TT-P-19	Latex
20	3	8.00	MIL-P-28582	Alkyd	TT-P-1510	Latex
21	8	7.83	TT-P-001984	Latex	TT-P-96	Latex
22	1	7.67	MIL-P-28582	Alkyd	TT-E-529	Alkyd

[a]Water-reducible alkyd.

Table E-5. Performance Ranking and Scores for Coating Systems After 4 Years at the Kwajalein Test Site (Chalking)

Rank	System Number	Score	Primer		Topcoat	
			Specification	Type	Specification	Type
1	10	9.33	TT-P-001984	Latex	UCAR 19-92-A	Latex
2	14	9.00	Sinclair AP8-11	Latex	Sinclair 4800	Latex
2	16	9.00	TT-P-001984	Latex	Standard Brands F6674-2	Latex
4	12	8.50	TT-P-001984	Latex	UCAR 19-92-C	Latex
4	13	8.50	TT-P-001984	Latex	UCAR 19-93-A	Latex
4	19	8.50	TT-P-001984	Latex	Standard Brands F6674-3	Latex
4	20	8.50	TT-P-001984	Latex	Standard Brands F6674-4	Latex
8	17	8.00	Sinclair AP8-11	Latex	Sinclair 4400	Latex
8	18	8.00	Sinclair AP8-11	Latex	Sinclair 1300	Latex
10	4	7.50	SUNCO	Latex	SUNCO	Latex
11	1	7.00	MIL-P-28582	Latex	TT-E-529	Alkyd
11	5	7.00	TT-P-001984	Latex	TT-E-529	Alkyd
11	11	7.00	TT-P-001984	Latex	UCAR 19-92-B	Latex
11	21	7.00	TT-P-001984	Latex	Standard Brands F6674-5	Latex
15	9	6.50	TT-P-001984	Latex	Ameritone W9900	Latex
16	3	6.00	MIL-P-28582	Alkyd	TT-P-1510	Latex
16	15	6.00	TT-P-001984	Latex	Standard Brands F6674-1	Latex
18	22	5.00	Amoco WS-549	Alkyd[a]	Amoco WS-549	Alkyd[a]
19	6	2.50	TT-P-001984	Latex	TT-P-19	Latex
20	7	2.00	TT-P-001984	Latex	TT-P-1510	Latex
20	8	2.00	TT-P-001984	Latex	TT-P-96	Latex
22	2	1.50	MIL-P-28582	Alkyd	TT-P-19	Latex

[a]Water-reducible alkyd.

Table E-6. Performance Ranking and Scores for Coating Systems After 3 Years at Kwajalein Test Site (Chalking)

Rank	System Number	Score	Primer		Topcoat	
			Specification	Type	Specification	Type
1	10	9.33	TT-P-001984	Latex	UCAR 19-92-A	Latex
2	12	9.17	TT-P-001984	Latex	UCAR 19-92-C	Latex
3	13	9.00	TT-P-001984	Latex	UCAR 19-93-A	Latex
3	17	9.00	Sinclair AP8-11	Latex	Sinclair 4400	Latex
5	14	8.50	Sinclair AP8-11	Latex	Sinclair 4800	Latex
5	20	8.50	TT-P-001984	Latex	Standard Brands F6674-4	Latex
7	18	7.50	Sinclair AP8-11	Latex	Sinclair 1300	Latex
7	19	7.50	TT-P-001984	Latex	Standard Brands F6674-3	Latex
9	11	7.00	TT-P-001984	Latex	UCAR 19-92-B	Latex
9	21	7.00	TT-P-001984	Latex	Standard Brands F6674-5	Latex
9	9	7.00	TT-P-001984	Latex	Ameritone W9900	Latex
9	5	7.00	TT-P-001984	Latex	TT-E-529	Alkyd
9	4	7.00	SUNCO	Latex	SUNCO	Latex
14	1	6.00	MIL-P-28582	Alkyd	TT-E-529	Alkyd
15	22	5.50	Amoco WS-549	Alkyd[a]	Amoco WS-549	Alkyd[a]
16	15	5.00	TT-P-001984	Latex	Standard Brands F6674-1	Latex
17	16	4.00	TT-P-001984	Latex	Standard Brands F6674-2	Latex
17	6	4.00	TT-P-28582	Alkyd	TT-P-19	Latex
19	3	3.00	MIL-P-28582	Alkyd	TT-P-1510	Latex
19	2	3.00	MIL-P-28582	Alkyd	TT-P-19	Latex
21	8	2.00	TT-P-001984	Latex	TT-P-96	Latex
21	7	2.00	TT-P-001984	Latex	TT-P-1510	Latex

[a]Water-reducible alkyd.

Table E-7. Performance Ranking and Scores for Coating Systems After 4 Years at the Kwajalein Test Site (Alligatoring, Checking)

Rank	System Number	Score	Primer		Topcoat	
			Specification	Type	Specification	Type
1	4	10.00	SUNCO	Latex	SUNCO	Latex
1	10	10.00	TT-P-001984	Latex	UCAR 19-92-A	Latex
1	12	10.00	TT-P-001984	Latex	UCAR 19-92-C	Latex
1	14	10.00	Sinclair AP8-11	Latex	Sinclair 4800	Latex
1	17	10.00	Sinclair AP8-11	Latex	Sinclair 4400	Latex
1	18	10.00	Sinclair AP8-11	Latex	Sinclair 1300	Latex
1	21	10.00	TT-P-001984	Latex	Standard Brands F6674-5	Latex
8	13	9.83	TT-P-001984	Latex	UCAR 19-93-A	Latex
8	19	9.83	TT-P-001984	Latex	Standard Brands F6674-3	Latex
10	15	9.50	TT-P-001984	Latex	Standard Brands F6674-1	Latex
10	20	9.50	TT-P-001984	Latex	Standard Brands F6674-4	Latex
12	16	9.33	TT-P-001984	Latex	Standard Brands F6674-2	Latex
13	11	8.00	TT-P-001984	Latex	UCAR 19-92-B	Latex
14	2	7 00	MIL-P-28582	Alkyd	TT-P-19	Latex
15	6	6.00	TT-P-001984	Latex	TT-P-19	Latex
15	9	6.00	TT-P-001984	Latex	Ameritone W9900	Latex
17	3	5.50	MIL-P-28582	Alkyd	TT-P-1510	Latex
18	1	5.00	MIL-P-28582	Alkyd	TT-E-529	Alkyd
18	7	5.00	TT-P-001984	Latex	TT-P-1510	Latex
18	8	5.00	TT-P-001984	Latex	TT-P-96	Latex
21	22	4.50	Amoco WS-549	Alkyd[a]	Amoco WS-549	Alkyd[a]
22	5	4.00	TT-P-001984	Latex	TT-E-529	Alkyd

[a]Water-reducible alkyd.

Table E-8. Performance Ranking and Scores for Coating Systems After 3 Years at the Kwajalein Test Site (Alligatoring, Checking)

Rank	System Number	Score	Primer		Topcoat	
			Specification	Type	Specification	Type
1	17	10.00	Sinclair AP8-11	Latex	Sinclair 4400	Latex
1	18	10.00	Sinclair AP8-11	Latex	Sinclair 1300	Latex
1	14	10.00	Sinclair AP8-11	Latex	Sinclair 4800	Latex
1	10	10.00	TT-P-001984	Latex	UCAR 19-92-A	Latex
1	12	10.00	TT-P-001984	Latex	UCAR 19-92-C	Latex
1	21	10.00	TT-P-001984	Latex	Standard Brands F6674-5	Latex
1	4	10.00	SUNCO	Latex	SUNCO	Latex
8	13	9.83	TT-P-001984	Latex	UCAR 19-93-A	Latex
8	19	9.83	TT-P-001984	Latex	Standard Brands F6674-3	Latex
10	20	9.50	TT-P-001984	Latex	Standard Brands F6674-4	Latex
12	16	9.00	TT-P-001984	Latex	Standard Brands F6674-2	Latex
17	2	7.00	MIL-P-28582	Alkyd	TT-P-19	Latex
14	9	6.00	TT-P-001984	Latex	Ameritone W9900	Latex
14	6	6.00	TT-P-001984	Latex	TT-P-19	Latex
14	7	6.00	TT-P-001984	Latex	TT-P-1510	Latex
14	3	6.00	MIL-P-28582	Alkyd	TT-P-1510	Latex
18	11	5.00	TT-P-001984	Latex	UCAR 19-92-B	Latex
18	5	5.00	TT-P-001984	Latex	TT-E-529	Alkyd
18	8	5.00	TT-P-001984	Latex	TT-P-96	Latex
18	1	5.00	MIL-P-28582	Alkyd	TT-E-529	Alkyd
18	22	5.00	Amoco WS-549	Alkyd[a]	Amoco WS-549	Alkyd[a]

[a]Water-reducible alkyd.

Table E-9. Performance Ranking and Scores for Coating Systems After 4 Years at the Kwajalein Test Site (Cracking)

Rank	System Number	Score	Primer		Topcoat	
			Specification	Type	Specification	Type
1	4	10.00	SUNCO	Latex	SUNCO	Latex
1	17	10.00	Sinclair AP8-11	Latex	Sinclair 4400	Latex
3	18	9.67	Sinclair AP8-11	Latex	Sinclair 1300	Latex
4	14	9.50	Sinclair AP8-11	Latex	Sinclair 4800	Latex
5	13	9.00	TT-P-001984	Latex	UCAR 19-93-A	Latex
5	19	9.00	TT-P-001984	Latex	Standard Brands F6674-3	Latex
7	12	8.00	TT-P-001984	Latex	UCAR 19-92-C	Latex
8	10	7.50	TT-P-001984	Latex	UCAR 19-92-A	Latex
9	21	7.00	TT-P-001984	Latex	Standard Brands F6674-5	Latex
10	11	6.50	TT-P-001984	Latex	UCAR 19-92-B	Latex
10	15	6.50	TT-P-001984	Latex	Standard Brands F6674-1	Latex
10	16	6.50	TT-P-001984	Latex	Standard Brands F6674-2	Latex
13	20	5.50	TT-P-001984	Latex	Standard Brands F6674-4	Latex
14	2	5.00	MIL-P-28582	Alkyd	TT-P-19	Latex
14	9	5.00	TT-P-001984	Latex	Ameritone W9900	Latex
16	3	4.50	MIL-P-28582	Alkyd	TT-P-1510	Latex
17	5	4.00	TT-P-001984	Latex	TT-E-529	Alkyd
17	6	4.00	TT-P-001984	Latex	TT-P-19	Latex
17	7	4.00	TT-P-001984	Latex	TT-P-1510	Latex
17	8	4.00	TT-P-001984	Latex	TT-P-96	Latex
17	22	4.00	Amoco WS-549	Alkyd[a]	Amoco WS-549	Alkyd[a]
22	1	3.50	MIL-P-28582	Alkyd	TT-E-529	Alkyd

[a]Water-reducible alkyd.

Table E-10. Performance Ranking and Scores for Coating Systems After 3 Years at the Kwajalein Test Site (Cracking)

Rank	System Number	Score	Primer		Topcoat	
			Specification	Type	Specification	Type
1	17	10.00	Sinclair AP8-11	Latex	Sinclair 4400	Latex
1	18	10.00	Sinclair AP8-11	Latex	Sinclair 1300	Latex
1	12	10.00	TT-P-001984	Latex	UCAR 19-92-C	Latex
1	4	10.00	SUNCO	Latex	SUNCO	Latex
5	14	9.50	Sinclair AP8-11	Latex	Sinclair 4800	Latex
6	13	9.00	TT-P-001984	Latex	UCAR 19-93-A	Latex
6	10	9.00	TT-P-001984	Latex	UCAR 19-92-A	Latex
6	19	9.00	TT-P-001984	Latex	Standard Brands F6674-3	Latex
9	21	8.00	TT-P-001984	Latex	Standard Brands F6674-5	Latex
10	11	7.00	TT-P-001984	Latex	UCAR 19-92-B	Latex
11	20	6.50	TT-P-001984	Latex	Standard Brands F6674-4	Latex
11	16	6.50	TT-P-001984	Latex	Standard Brands F6674-2	Latex
11	15	6.50	TT-P-001984	Latex	Standard Brands F6674-1	Latex
14	9	5.00	TT-P-001984	Latex	Ameritone W9900	Latex
14	6	5.00	TT-P-001984	Latex	TT-P-19	Latex
14	3	5.00	TT-P-001984	Alkyd	TT-P-1510	Latex
14	2	5.00	MIL-P-28582	Alkyd	TT-P-19	Latex
18	8	4.00	TT-P-001984	Latex	TT-P-96	Latex
18	7	4.00	TT-P-001984	Latex	TT-P-1510	Latex
18	5	4.00	TT-P-001984	Latex	TT-E-529	Alkyd
18	22	4.00	Amoco WS-549	Alkyd[a]	Amoco WS-549	Alkyd[a]
22	1	3.50	MIL-P-28582	Alkyd	TT-E-529	Alkyd

[a]Water-reducible alkyd.

Table E-11. Performance Ranking and Scores for Coating Systems After 4 Years at the Kwajalein Test Site (Scaling, Flaking, Peeling)

Rank	System Number	Score	Primer		Topcoat	
			Specification	Type	Specification	Type
1	4	10.00	SUNCO	Latex	SUNCO	Latex
1	10	10.00	TT-P-001984	Latex	UCAR 19-92-A	Latex
1	13	10.00	TT-P-001984	Latex	UCAR 19-93-A	Latex
1	14	10.00	Sinclair AP8-11	Latex	Sinclair 4800	Latex
1	17	10.00	Sinclair AP8-11	Latex	Sinclair 4400	Latex
1	18	10.00	Sinclair AP8-11	Latex	Sinclair 1300	Latex
1	20	10.00	TT-P-001984	Latex	Standard Brands F6674-4	Latex
1	21	10.00	TT-P-001984	Latex	Standard Brands F6674-5	Latex
9	16	9.83	TT-P-001984	Latex	Standard Brands F6674-2	Latex
9	19	9.83	TT-P-001984	Latex	Standard Brands F6674-3	Latex
11	12	9.50	TT-P-001984	Latex	UCAR 19-92-C	Latex
11	15	9.50	TT-P-001984	Latex	Standard Brands F6674-1	Latex
13	8	9.33	TT-P-001984	Latex	TT-P-96	Latex
14	2	9.00	MIL-P-28582	Alkyd	TT-P-19	Latex
14	7	9.00	TT-P-001984	Latex	TT-P-1510	Latex
14	9	9.00	TT-P-001984	Latex	Ameritone W9900	Latex
17	5	7.00	TT-P-001984	Latex	TT-E-529	Alkyd
17	11	7.00	TT-P-001984	Latex	UCAR 19-92-B	Latex
19	6	6.67	TT-P-001984	Latex	TT-P-19	Latex
20	3	6.50	MIL-P-28582	Alkyd	TT-P-1510	Latex
21	22	4.00	Amoco WS-549	Alkyd[a]	Amoco WS-549	Alkyd[a]
22	1	3.00	MIL-P-28582	Alkyd	TT-E-529	Alkyd

[a]Water-reducible alkyd.

Table E-12. Performance Ranking and Scores for Coating Systems After 3 Years at the Kwajalein Test Site (Scaling, Flaking, Peeling)

Rank	System Number	Score	Primer		Topcoat	
			Specification	Type	Specification	Type
1	18	10.00	Sinclair AP8-11	Latex	Sinclair 1300	Latex
1	17	10.00	Sinclair AP8-11	Latex	Sinclair 4400	Latex
1	14	10.00	Sinclair AP8-11	Latex	Sinclair 4800	Latex
1	13	10.00	TT-P-001984	Latex	UCAR 19-93-A	Latex
1	12	10.00	TT-P-001984	Latex	UCAR 19-92-C	Latex
1	11	10.00	TT-P-001984	Latex	UCAR 19-92-B	Latex
1	10	10.00	TT-P-001984	Latex	UCAR 19-92-A	Latex
1	4	10.00	SUNCO	Latex	SUNCO	Latex
1	21	8.00	TT-P-001984	Latex	Standard Brands F6674-5	Latex
1	20	10.00	TT-P-001984	Latex	Standard Brands F6674-4	Latex
11	19	9.83	TT-P-001984	Latex	Standard Brands F6674-3	Latex
11	16	9.83	TT-P-001984	Latex	Standard Brands F6674-2	Latex
13	15	9.50	TT-P-001984	Latex	Standard Brands F6674-1	Latex
13	7	9.50	TT-P-001984	Latex	TT-P-1510	Latex
15	8	9.33	TT-P-001984	Latex	TT-P-96	Latex
16	9	9.00	TT-P-001984	Latex	Ameritone W9900	Latex
16	2	9.00	MIL-P-28582	Alkyd	TT-P-19	Latex
18	6	8.00	TT-P-001984	Latex	TT-P-19	Latex
18	5	8.00	TT-P-001984	Latex	TT-E-529	Alkyd
20	3	7.00	MIL-P-28582	Alkyd	TT-P-1510	Latex
21	22	6.00	Amoco WS-549	Alkyd[a]	Amoco WS-549	Alkyd[a]
22	1	3.00	MIL-P-28582	Alkyd	TT-E-529	Alkyd

[a]Water-reducible alkyd.

Table E-13. Performance Ranking and Scores for Coating Systems After 4 Years at the Kwajalein Test Site (Erosion)

Rank	System Number	Score	Primer		Topcoat	
			Specification	Type	Specification	Type
1	18	9.66	Sinclair AP8-11	Latex	Sinclair 1300	Latex
2	4	9.50	SUNCO	Latex	SUNCO	Latex
2	16	9.50	TT-P-001984	Latex	Standard Brands F6674-2	Latex
4	17	9.33	Sinclair AP8-11	Latex	Sinclair 4400	Latex
5	10	9.17	TT-P-001984	Latex	UCAR 19-92-A	Latex
5	13	9.17	TT-P-001984	Latex	UCAR 19-93-A	Latex
7	12	9.00	TT-P-001984	Latex	UCAR 19-92-C	Latex
7	15	9.00	TT-P-001984	Latex	Standard Brands F6674-1	Latex
9	14	8.67	Sinclair AP8-11	Latex	Sinclair 4800	Latex
9	19	8.67	TT-P-001984	Latex	Standard Brands F6674-3	Latex
9	21	8.67	TT-P-001984	Latex	Standard Brands F6674-5	Latex
12	7	8.33	TT-P-001984	Latex	TT-P-1510	Latex
13	9	8.17	TT-P-001984	Latex	Ameritone W9900	Latex
14	2	8.00	MIL-P-28582	Alkyd	TT-P-19	Latex
14	6	8.00	TT-P-001984	Latex	TT-P-19	Latex
14	11	8.00	TT-P-001984	Latex	UCAR 19-92-B	Latex
17	20	7.50	TT-P-001984	Latex	Standard Brands F6674-4	Latex
18	3	7.00	MIL-P-28582	Alkyd	TT-P-1510	Latex
18	8	7.00	TT-P-001984	Latex	TT-P-96	Latex
20	5	6.50	TT-P-001984	Latex	TT-E-529	Alkyd
21	1	6.00	MIL-P-28582	Alkyd	TT-E-529	Alkyd
22	22	5.00	Amoco WS-549	Alkyd[a]	Amoco WS-549	Alkyd[a]

[a]Water-reducible alkyd.

Table E-14. Performance Ranking and Scores for Coating Systems After 3 Years at the Kwajalein Test Site (Erosion)

Rank	System Number	Score	Primer		Topcoat	
			Specification	Type	Specification	Type
1	18	9.66	Sinclair AP8-11	Latex	Sinclair 1300	Latex
1	4	9.66	SUNCO	Latex	SUNCO	Latex
3	17	9.50	Sinclair AP8-11	Latex	Sinclair 4400	Latex
3	16	9.50	TT-P-001984	Latex	Standard Brands F6674-2	Latex
5	12	9.33	TT-P-001984	Latex	UCAR 19-92-C	Latex
5	10	9.33	TT-P-001984	Latex	UCAR 19-92-A	Latex
7	15	9.17	TT-P-001984	Latex	Standard Brands F6674-1	Latex
7	13	9.17	TT-P-001984	Latex	UCAR 19-93-A	Latex
9	7	9.00	TT-P-001984	Latex	TT-P-1510	Latex
10	21	8.83	TT-P-001984	Latex	Standard Brands F6674-5	Latex
10	19	8.83	TT-P-001984	Latex	Standard Brands F6674-3	Latex
10	14	8.83	Sinclair AP8-11	Latex	Sinclair 4800	Latex
13	9	8.67	TT-P-001984	Latex	Ameritone W9900	Latex
14	20	8.50	TT-P-001984	Latex	Standard Brands F6674-4	Latex
14	11	8.50	TT-P-001984	Latex	UCAR 19-92-B	Latex
14	8	8.50	TT-P-001984	Latex	TT-P-96	Latex
17	6	8.00	TT-P-001984	Latex	TT-P-19	Latex
17	5	8.00	TT-P-001984	Latex	TT-E-529	Alkyd
17	2	8.00	MIL-P-28582	Alkyd	TT-P-19	Latex
20	3	7.50	MIL-P-28582	Alkyd	TT-P-1510	Latex
21	1	6.00	MIL-P-28582	Alkyd	TT-E-529	Alkyd
21	22	6.00	Amoco WS-549	Alkyd[a]	Amoco WS-549	Alkyd[a]

[a]Water-reducible alkyd.

Table E-15. Performance Ranking and Scores for Coating Systems After 4 Years at the Kwajalein Test Site (Blistering)

Rank	System Number	Score	Primer		Topcoat	
			Specification	Type	Specification	Type
1	1	10.00	MIL-P-?8582	Alkyd	TT-E-529	Alkyd
1	2	10.00	MIL-P-28582	Alkyd	TT-P-19	Latex
1	3	10.00	MIL-P-28582	Alkyd	TT-P-1510	Latex
1	4	10.00	SUNCO	Latex	SUNCO	Latex
1	5	10.00	TT-P-001984	Latex	TT-E-529	Alkyd
1	6	10.00	TT-P-001984	Latex	TT-P-19	Latex
1	7	10.00	TT-P-001984	Latex	TT-P-1510	Latex
1	8	10.00	TT-P-001984	Latex	TT-P-96	Latex
1	9	10.00	TT-P-001984	Latex	Ameritone W9900	Latex
1	10	10.00	TT-P-001984	Latex	UCAR 19-92-A	Latex
1	11	10.00	TT-P-001984	Latex	UCAR 19-92-B	Latex
1	12	10.00	TT-P-001984	Latex	UCAR 19-92-C	Latex
1	13	10.00	TT-P-001984	Latex	UCAR 19-93-A	Latex
1	14	10.00	Sinclair AP8-11	Latex	Sinclair 4800	Latex
1	15	10.00	TT-P-001984	Latex	Standard Brands F6674-1	Latex
1	16	10.00	TT-P-001984	Latex	Standard Brands F6674-2	Latex
1	17	10.00	Sinclair AP8-11	Latex	Sinclair 4400	Latex
1	18	10.00	Sinclair AP8-11	Latex	Sinclair 1300	Latex
1	19	10.00	TT-P-001984	Latex	Standard Brands F6674-3	Latex
1	20	10.00	TT-P-001984	Latex	Standard Brands F6674-4	Latex
1	21	10.00	TT-P-001984	Latex	Standard Brands F6674-5	Latex
1	22	10.00	Amoco WS-549	Alkyd[a]	Amoco WS-549	Alkyd[a]

[a]Water-reducible alkyd.

Table E-16. Performance Ranking and Scores for Coating Systems After 3 Years at the Kwajalein Test Site (Blistering)

Rank	System Number	Score	Primer		Topcoat	
			Specification	Type	Specification	Type
1	1	10.00	MIL-P-28582	Alkyd	TT-E-529	Alkyd
1	2	10.00	MIL-P-28582	Alkyd	TT-P-19	Latex
1	3	10.00	MIL-P-28582	Alkyd	TT-P-1510	Latex
1	4	10.00	SUNCO	Latex	SUNCO	Latex
1	5	10.00	TT-P-001984	Latex	TT-E-529	Alkyd
1	6	10.00	TT-P-001984	Latex	TT-P-19	Latex
1	7	10.00	TT-P-001984	Latex	TT-P-1510	Latex
1	8	10.00	TT-P-001984	Latex	TT-P-96	Latex
1	9	10.00	TT-P-001984	Latex	Ameritone W9900	Latex
1	10	10.00	TT-P-001984	Latex	UCAR 19-92-A	Latex
1	11	10.00	TT-P-001984	Latex	UCAR 19-92-B	Latex
1	12	10.00	TT-P-001984	Latex	UCAR 19-92-C	Latex
1	13	10.00	TT-P-001984	Latex	UCAR 19-93-A	Latex
1	14	10.00	SINCLAIR AP8-11	Latex	SINCLAIR 4800	Latex
1	15	10.00	TT-P-001984	Latex	Standard Brands F6674-1	Latex
1	16	10.00	TT-P-001984	Latex	Standard Brands F6674-2	Latex
1	17	10.00	SINCLAIR AP811	Latex	SINCLAIR 4400	Latex
1	18	10.00	SINCLAIR AP8-11	Latex	SINCLAIR 1300	Latex
1	19	10.00	TT-P-001984	Latex	Standard Brands F6674-3	Latex
1	20	10.00	TT-P-001984	Latex	Standard Brands F6674-4	Latex
1	21	10.00	TT-P-001984	Latex	Standard Brands F6674-5	Latex
1	22	10.00	Amoco WS-549	Alkyd[a]	Amoco WS-549	Alkyd[a]

[a]Water-reducible alkyd.

Table E-17. Performance Ranking and Scores for Coating Systems After 4 Years at the Kwajalein Test Site (Mildew)

Rank	System Number	Score	Primer		Topcoat	
			Specification	Type	Specification	Type
1	1	10.00	MIL-P-28582	Alkyd	TT-E-529	Alkyd
1	2	10.00	MIL-P-28582	Alkyd	TT-P-19	Latex
1	3	10.00	MIL-P-28582	Alkyd	TT-P-1510	Latex
1	4	10.00	SUNCO	Latex	SUNCO	Latex
1	5	10.00	TT-P-001984	Latex	TT-E-529	Alkyd
1	6	10.00	TT-P-001984	Latex	TT-P-19	Latex
1	7	10.00	TT-P-001984	Latex	TT-P-1510	Latex
1	8	10.00	TT-P-001984	Latex	TT-P-96	Latex
1	9	10.00	TT-P-001984	Latex	Ameritone W9900	Latex
1	10	10.00	TT-P-001984	Latex	UCAR 19-92-A	Latex
1	11	10.00	TT-P-001984	Latex	UCAR 19-92-B	Latex
1	12	10.00	TT-P-001984	Latex	UCAR 19-92-C	Latex
1	13	10.00	TT-P-001984	Latex	UCAR 19-93-A	Latex
1	14	10.00	Sinclair AP8-11	Latex	Sinclair 4800	Latex
1	15	10.00	TT-P-001984	Latex	Standard Brands F6674-1	Latex
1	16	10.00	TT-P-001984	Latex	Standard Brands F6674-2	Latex
1	17	10.00	Sinclair AP8-11	Latex	Sinclair 4400	Latex
1	18	10.00	Sinclair AP8-11	Latex	Sinclair 1300	Latex
1	19	10.00	TT-P-001984	Latex	Standard Brands F6674-3	Latex
1	20	10.00	TT-P-001984	Latex	Standard Brands F6674-4	Latex
1	21	10.00	TT-P-001984	Latex	Standard Brands F6674-5	Latex
1	22	10.00	Amoco WS-549	Alkyd[a]	Amoco WS-549	Alkyd[a]

[a]Water-reducible alkyd.

Table E-18. Performance Ranking and Scores for Coating Systems After 3 Years at the Kwajalein Test Site (Mildew)

Rank	System Number	Score	Primer		Topcoat	
			Specification	Type	Specification	Type
1	1	10.00	MIL-P-28582	Alkyd	TT-E-529	Alkyd
1	2	10.00	MIL-P-28582	Alkyd	TT-P-19	Latex
1	3	10.00	MIL-P-28582	Alkyd	TT-P-1510	Latex
1	4	10.00	SUNCO	Latex	SUNCO	Latex
1	5	10.00	TT-P-001984	Latex	TT-E-529	Alkyd
1	6	10.00	TT-P-001984	Latex	TT-P-19	Latex
1	7	10.00	TT-P-001984	Latex	TT-P-1510	Latex
1	8	10.00	TT-P-001984	Latex	TT-P-96	Latex
1	9	10.00	TT-P-001984	Latex	Ameritone W9900	Latex
1	10	10.00	TT-P-001984	Latex	UCAR 19-92-A	Latex
1	11	10.00	TT-P-001984	Latex	UCAR 19-92-B	Latex
1	12	10.00	TT-P-001984	Latex	UCAR 19-92-C	Latex
1	13	10.00	TT-P-001984	Latex	UCAR 19-93-A	Latex
1	14	10.00	Sinclair AP8-11	Latex	Sinclair 4800	Latex
1	15	10.00	TT-P-001984	Latex	Standard Brands F6674-1	Latex
1	16	10.00	TT-P-001984	Latex	Standard Brands F6674-2	Latex
1	17	10.00	Sinclair AP8-11	Latex	Sinclair 4400	Latex
1	18	10.00	Sinclair AP8-11	Latex	Sinclair 1300	Latex
1	19	10.00	TT-P-001984	Latex	Standard Brands F6674-3	Latex
1	20	10.00	TT-P-001984	Latex	Standard Brands F6674-4	Latex
1	21	10.00	TT-P-001984	Latex	Standard Brands F6674-5	Latex
1	22	10.00	Amoco WS-549	Alkyd[a]	Amoco WS-549	Alkyd[a]

[a]Water-reducible alkyd.

Appendix F

OVERALL PERFORMANCE RANKING OF COATINGS EXPOSED FOR 1, 2, 3, AND 4 YEARS

Table F-1. Overall Performance Ranking and Scores for Coating Systems After 1 year of Exposure

Rank	System Number	Score	Primer		Topcoat	
			Specification	Type	Specification	Type
1	10	9.90	TT-P-001984	Latex	UCAR 19-92-A	Latex
2	12	9.85	TT-P-001984	Latex	UCAR 19-92-C	Latex
3	17	9.83	Sinclair AP8-11	Latex	Sinclair 4400	Latex
4	20	9.80	TT-P-001984	Latex	Standard Brands F6674-4	Latex
5	4	9.78	SUNCO	Latex	SUNCO	Latex
6	19	9.77	TT-P-001984	Latex	Standard Brands F6674-3	Latex
6	21	9.77	TT-P-001984	Latex	Standard Brands F6674-5	Latex
8	14	9.76	Sinclair AP8-11	Latex	Sinclair 4800	Latex
9	11	9.73	TT-P-001984	Latex	UCAR 19-92-B	Latex
10	10	9.72	TT-P-001984	Latex	UCAR 19-92-A	Latex
11	18	9.71	Sinclair AP8-11	Latex	Sinclair 1300	Latex
12	13	9.64	TT-P-001984	Latex	UCAR 19-93-A	Latex
13	5	9.59	TT-P-001984	Latex	TT-E-529	Alkyd
14	15	9.45	TT-P-001984	Latex	Standard Brands F6674-1	Latex
15	9	9.39	TT-P-001984	Latex	Ameritone W9900	Latex
16	1	9.36	MIL-P-28582	Alkyd	TT-E-529	Alkyd
16	6	9.36	TT-P-001984	Latex	TT-P-19	Latex
18	3	9.14	MIL-P-28582	Alkyd	TT-P-1510	Latex
19	2	9.09	MIL-P-28582	Alkyd	TT-P-19	Latex
20	7	9.04	TT-P-001984	Latex	TT-P-1510	Latex
20	22	9.04	Amoco WS-549	Alkyd[a]	Amoco WS-549	Alkyd[a]
22	8	8.09	TT-P-001984	Latex	TT-P-96	Latex

[a]Water-reducible alkyd.

Table F-2. Performance Ranking and Scores for Coating Systems After 2 Years of Exposure

Rank	System Number	Score	Primer		Topcoat	
			Specification	Type	Specification	Type
1	14	9.84	Sinclair AP8-11	Latex	Sinclair 4800	Latex
2	17	9.77	Sinclair AP8-11	Latex	Sinclair 4400	Latex
3	18	9.76	Sinclair AP8-11	Latex	Sinclair 1300	Latex
4	4	9.70	SUNCO	Latex	SUNCO	Latex
5	19	9.70	TT-P-001984	Latex	Standard Brands F6674-3	Latex
6	10	9.70	TT-P-001984	Latex	UCAR 19-92-A	Latex
7	13	9.56	TT-P-001984	Latex	UCAR 19-93-A	Latex
8	21	9.54	TT-P-001984	Latex	Standard Brands F6674-5	Latex
9	12	9.48	TT-P-001984	Latex	UCAR 19-92-C	Latex
10	16	9.45	TT-P-001984	Latex	Standard Brands F6674-2	Latex
11	20	9.43	TT-P-001984	Latex	Standard Brands F6674-4	Latex
12	11	9.39	TT-P-001984	Latex	UCAR 19-92-B	Latex
13	15	8.98	TT-P-001984	Latex	Standard Brands F6674-1	Latex
14	9	8.96	TT-P-001984	Latex	Ameritone 89900	Latex
15	5	8.92	TT-P-001984	Latex	TT-E-529	Alkyd
16	2	8.47	MIL-P-28582	Alkyd	TT-P-19	Latex
17	22	8.45	Amoco WS-549	Alkyd[a]	Amoco WS-549	Alkyd[a]
18	7	8.37	TT-P-001984	Latex	TT-P-1510	Latex
19	6	8.28	TT-P-001984	Latex	TT-P-19	Latex
20	1	8.22	MIL-P-28582	Alkyd	TT-E-529	Alkyd
21	3	8.14	MIL-P-28582	Alkyd	TT-P-1510	Latex
22	8	7.53	TT-P-001984	Latex	TT-P-96	Latex

[a]Water-reducible alkyd.

Table F-3. Overall Performance Ranking and Scores for Coating Systems After 3 Years of Exposure

Rank	System Number	Score	Primer		Topcoat	
			Specification	Type	Specification	Type
1	17	9.68	Sinclair AP8-11	Latex	Sinclair 4400	Latex
1	12	9.68	TT-P-001984	Latex	UCAR 19-92-C	Latex
3	18	9.57	Sinclair AP8-11	Latex	Sinclair 1300	Latex
4	13	9.52	TT-P-001984	Latex	UCAR 19-93-A	Latex
4	10	9.52	TT-P-001984	Latex	UCAR 19-92-A	Latex
6	4	9.48	SUNCO	Latex	SUNCO	Latex
7	14	9.46	Sinclair AP8-11	Latex	Sinclair 4800	Latex
8	19	9.29	TT-P-001984	Latex	Standard Brands F6674-3	Latex
9	21	9.18	TT-P-001984	Latex	Standard Brands F6674-5	Latex
10	20	8.94	TT-P-001984	Latex	Standard Brands F6674-4	Latex
11	15	8.63	TT-P-001984	Latex	Standard Brands F6674-1	Latex
12	16	8.54	TT-P-001984	Latex	Standard Brands F6674-2	Latex
13	11	8.42	TT-P-001984	Latex	UCAR 19-92-B	Latex
14	9	8.17	TT-P-001984	Latex	Ameritone W990C	Latex
15	5	7.74	TT-P-001984	Latex	TT-E-529	Alkyd
16	2	7.61	MIL-P-28582	Alkyd	TT-P-19	Latex
17	7	7.55	TT-P-001984	Latex	T-P-1510	Latex
18	6	7.52	TT-P-001984	Latex	TT-P-19	Latex
19	3	7.18	MIL-P-28582	Alkyd	TT-P-1510	Latex
19	8	7.18	TT-P-001984	Latex	TT-P-96	Latex
21	22	7.00	Amoco WS-549	Alkyd[a]	Amoco WS-549	Alkyd[a]
22	1	6.46	MIL-P-28582	Alkyd	TT-E-529	Alkyd

[a]Water reducible alkyd.

Table F-4. Overall Performance Ranking and Scores for Coating Systems After 4 Years of Exposure

Rank	System Number	Score	Primer		Topcoat	
			Specification	Type	Specification	Type
1	18	9.60	Sinclair AP8-11	Latex	Sinclair 1300	Latex
2	4	9.54	SUNCO	Latex	SUNCO	Latex
2	17	9.54	Sinclair AP8-11	Latex	Sinclair 4400	Latex
4	14	9.46	Sinclair AP8-11	Latex	Sinclair 4800	Latex
5	13	9.44	TT-P-001984	Latex	UCAR 19-93-A	Latex
6	19	9.31	TT-P-001984	Latex	Standard Brands F6674-3	Latex
7	10	9.24	TT-P-001984	Latex	UCAR 19-92-A	Latex
8	12	9.20	TT-P-001984	Latex	UCAR 19-92-C	Latex
9	16	9.17	TT-P-001984	Latex	Standard Brands F6674-2	Latex
10	21	9.04	TT-P-001984	Latex	Standard Brands F6674-5	Latex
11	15	8.72	TT-P-001984	Latex	Standard Brands F6674-1	Latex
12	20	8.63	TT-P-001984	Latex	Standard Brands F6674-4	Latex
13	11	8.18	TT-P-001984	Latex	UCAR 19-92-B	Latex
14	9	7.98	TT-P-001984	Latex	Ameritone W9900	Latex
15	2	7.37	MIL-P-28582	Alkyd	TT-P-19	Latex
16	3	7.28	MIL-P-28582	Alkyd	TT-P-1510	Latex
16	7	7.28	TT-P-001984	Latex	TT-P-1510	Latex
18	5	7.20	TT-P-001984	Latex	TT-E-529	Alkyd
19	6	7.07	TT-P-001984	Latex	TT-P-19	Latex
20	8	7.02	TT-P-001984	Latex	TT-P-96	Latex
21	1	6.52	MIL-P-28582	Alkyd	TT-E-529	Alkyd
22	22	6.31	Amoco WS-549	Alkyd[a]	Amoco WS-549	Alkyd[a]

[a]Water-reducible alkyd.

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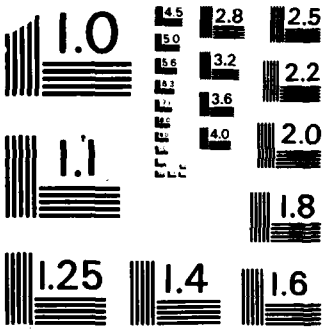

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Appendix G

COMPOSITION AND PERFORMANCE DATA OF TOP PERFORMING LATEX COATINGS

Table G-1. Composition and Performance Data of System 18 Primer

Test[a]	Results
Condition in container	Conforms
Weight per gallon, lb	10
Pigment content, % by weight	26
Total solids, % by weight	52.2
Drying time set-to-touch, hr	1/4
Dry hard, hr	3/4
Dry opacity contrast ratio-White paint	0.98
Storage stability[b]	
Daylight directional reflectance, %	91.4
Consistency, KU	82
Fineness of grind, NS	6
Scrub resistance[b]	
Analysis of titanium dioxide, % by pigment	51
Analysis of zinc oxide, % by pigment	8.2
Lead content (% nonvolatile basis)	<0.01
Vehicle	Conforms
Freeze-thaw stability[b]	
Heat stability	Conforms
Application properties and appearance	Conforms
Accelerated-weathering resistance	Conforms
Yellowness index	0.04
Color difference of opaque materials	2.6
Fungus resistance[b]	
Volatile organic content (VOC)	<250
Flexibility	Conforms
Adhesion (Tape method)	Conforms
Stain resistance	Conforms
Sealing properties	Conforms

[a] Test methods listed in TT-P-001984 and TT-P-19 were used as appropriate.

[b] Not tested.

Table G-2. Composition and Performance Data of System 18 Topcoat

Test[a]	Results
Condition in container	Conforms
Weight per gallon, lb	11.7
Pigment content, % by weight	46.0
Total solids, % by weight	64.2
Drying time set-to-touch, hr	1/4
Dry hard, hr	3/4
Dry opacity contrast ratio-White paint	0.98
Storage stability[b]	
Daylight directional reflectance, %	91.5
Consistency, KU	93
Fineness of grind, NS	5
Scrub resistance[b]	
Analysis of titanium dioxide, % by pigment	51
Analysis of zinc oxide, % by pigment	<1
Lead content (% nonvolatile basis)	<0.01
Vehicle	Conforms
Freeze-thaw stability[b]	
Heat stability	(131 K.U.)
Application properties and appearance	Conforms
Accelerated-weathering resistance	Conforms
Yellowness index	0.06
Color difference of opaque materials	2.83
Fungus resistance[b]	
Volatile organic content (VOC)	<250
Flexibility	Conforms
Adhesion (Tape method)	Conforms
Stain resistance	Conforms
Sealing properties	Conforms

[a]Test methods listed in TT-P-001984 and TT-P-19 were used as appropriate.

[b]Not tested.

Table G-3. Composition and Performance Data of System 17 Topcoat

(Primer same as System 18)

Test[a]	Results
Condition in container	Conforms
Weight per gallon, lb	11
Pigment content, % by weight	26
Total solids, % by weight	52.5
Drying time set-to-touch, hr	1/4
Dry hard, hr	3/4
Dry opacity contrast ratio-White paint	0.98
Storage stability[b]	
Daylight directional reflectance, %	90.5
Consistency, KU	79
Fineness of grind, NS	7
Scrub resistance[b]	
Analysis of titanium dioxide, % by pigment	80
Analysis of zinc oxide, % by pigment	<1
Lead content (% nonvolatile basis)	<0.01
Vehicle	Conforms
Freeze-thaw stability[b]	
Heat stability	Conforms
Application properties and appearance	Conforms
Accelerated-weathering resistance	Conforms
Yellowness index	0.06
Color difference of opaque materials	2.54
Fungus resistance[b]	
Volatile organic content (VOC)	<250
Flexibility	Conforms
Adhesion (Tape method)	Conforms
Stain resistance	Conforms
Sealing properties	Conforms

[a]Test methods listed in TT-P-001984 and TT-P-19 were used as appropriate.

[b]Not tested.

Appendix H

BONDING STRENGTHS OF COATINGS ON PLYWOOD BEFORE AND AFTER 4 YEARS OF FIELD EXPOSURE

System Number	Bonding Strength (kg/cm^2)						Average Bonding Strength (kg/cm^2)		
	Initial		After 2 Years		After 4 Years		Initial	After 2 Years	After 4 Years
	Rough-Sawn Wood	Smooth Wood	Rough-Sawn Wood	Smooth Wood	Rough-Sawn Wood	Smooth Wood			
1	15.2	11.5	17.7	10.9	13.2	10.6	13.4	14.3	11.9
2	15.2	8.7	16.0	26.9	10.1	8.7	12.0	21.5	9.4
3	16.4	8.8	13.2	10.3	16.9	11.7	12.6	11.8	14.3
4	14.2	13.0	20.6	18.6	20.4	32.4	13.6	19.6	26.4
5	22.2	21.7	15.4	21.1	17.6	13.5	21.2	18.3	15.6
6	13.9	11.8	14.1	25.2	14.7	17.0	12.9	19.7	15.8
7	20.2	9.2	21.1	16.5	19.7	18.3	14.7	18.8	19.0
8	16.9	9.3	20.8	12.1	18.1	15.4	13.1	16.5	16.7
9	19.7	12.5	16.8	15.2	20.9	16.4	16.1	16.0	18.6
10	17.8	13.5	18.1	15.5	26.4	19.8	15.7	16.8	23.1
11	21.8	18.1	23.5	42.2	17.0	24.9	20.0	32.9	21.0
12	21.9	20.4	16.5	19.7	19.7	14.7	21.2	18.1	17.2
13	16.9	10.5	40.2	15.1	26.4	13.5	13.7	27.7	20.0
14	14.7	9.8	18.9	22.1	22.5	16.0	12.3	20.5	19.2
15	20.1	11.1	19.4	26.7	21.3	20.0	15.6	23.1	20.6
16	28.9	13.3	21.9	25.9	26.9	18.9	21.1	23.9	22.9
17	21.7	24.6	26.7	20.6	21.9	16.9	23.2	23.7	19.4
18	21.0	12.4	22.5	18.8	20.1	12.5	16.7	20.7	16.3
19	15.0	11.8	16.7	20.5	20.1	22.4	13.4	18.6	21.3
20	20.3	12.3	28.7	17.3	16.3	15.4	16.3	23.0	15.9
21	24.5	10.6	29.3	15.5	18.2	14.9	17.6	22.4	16.6
22	19.4	19.3	16.9	22.6	19.1	14.5	19.4	19.8	16.8
Average	19.2	13.4	20.7	20.0	19.4	16.8	16.2	20.4	18.1

Appendix I

AVERAGE PENETRATION OF COATING INTO WOOD

System Number	Penetration of Coating into Wood (μm)			Average Penetration Rank
	Rough-Sawn Wood	Smooth Wood	Average	
1	160.2	75.9	118.5	16
2	36.7	53.0	44.9	22
3	97.1	33.0	65.1	19
4	246.7	164.5	205.6	1
5	141.3	108.1	124.7	13
6	151.1	146.9	149.0	6
7	47.4	129.6	88.5	18
8	70.5	45.6	58.1	20
9	184.8	162.5	173.7	3
10	216.0	109.9	163.0	4
11	236.2	87.2	161.7	5
12	209.9	75.1	141.0	9
13	84.9	200.4	142.7	8
14	155.8	223.7	189.8	2
15	143.2	116.1	129.7	11
16	133.9	131.6	132.8	10
17	176.2	112.1	144.2	7
18	198.8	39.3	119.1	15
19	178.7	25.4	102.1	17
20	53.1	45.3	49.2	21
21	106.8	137.6	122.2	14
22	146.8	107.2	127.0	12
Average	144.4	105.9	125.2	

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